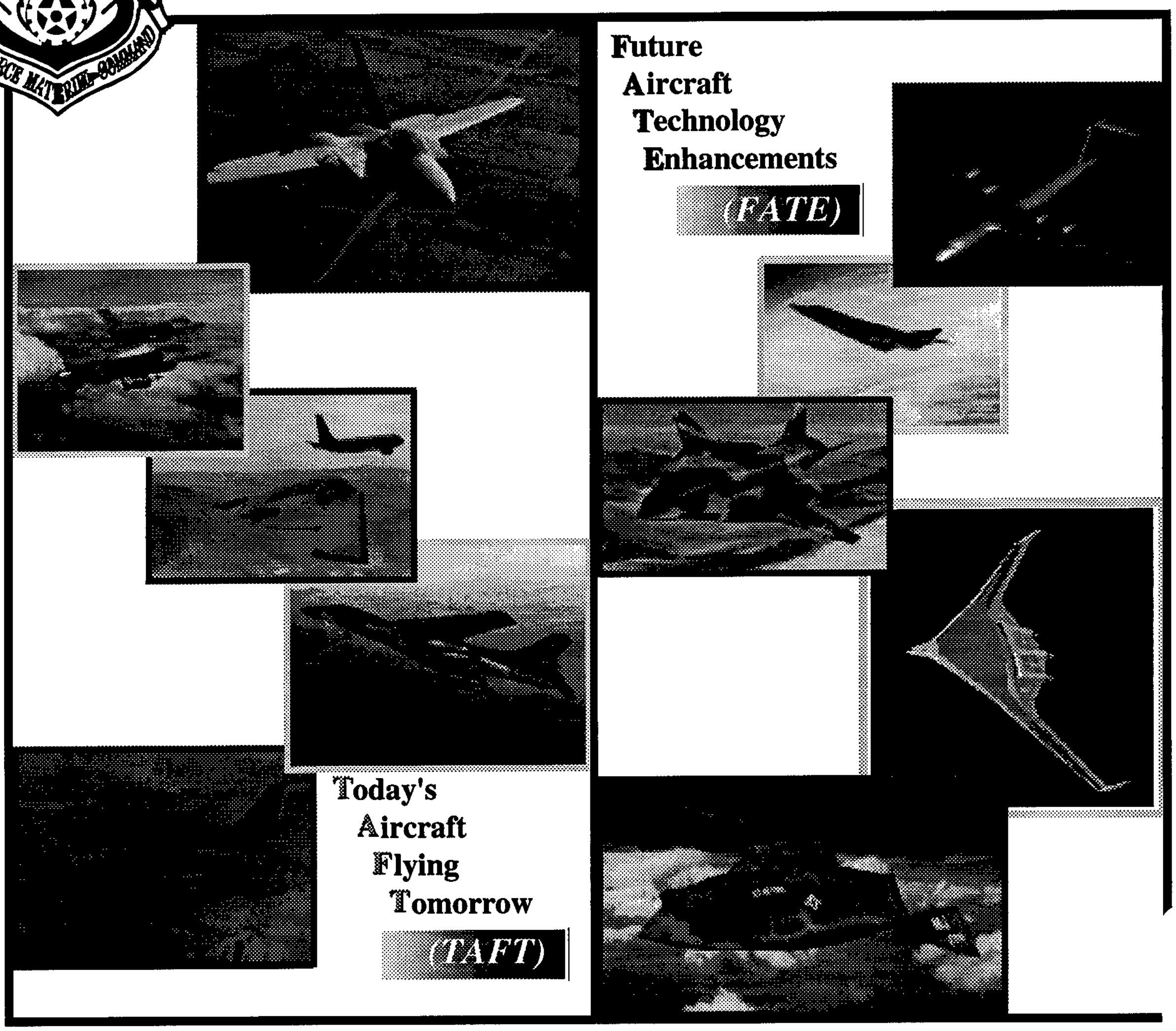
FY98
AIR VEHICLES
TECHNOLOGY AREA PLAN



AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AFB OH

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About the cover:

This composite photograph depicts a collection of fixed wing air vehicles and conceptual designs that have and will benefit from the development of air vehicles technologies. The Air Vehicles Technology Area continues to address the current fleet needs and at the same time develop revolutionary technologies that will satisfy the requirements for the next generation warfighters. In order to accomplish these tasks two new technology emphases are established: Today's Aircraft Flying Tomorrow or **TAFT**; and Future Aircraft Technology Enhancements or **FATE**.

TAFT extends the capability of the current fleet beyond its projected operational life through the development and transition of advanced technologies. Technologies supporting **TAFT** include survivable aircraft structures, weapons bay noise suppression, extended life tires, and structural life extension techniques such as development of corrosion sensing and monitoring systems.

FATE develops revolutionary technologies that will become the foundation for next generation warfighters. These new systems will provide the US with air and space superiority into the 21st century. Examples of **FATE** technologies include affordable LO data system, active aeroelastic wing, robust composite sandwich structures, advanced compact inlets, photonic vehicle management systems, self-adaptive flight controls, and electric actuation, to mention some.

Note: This Technology Area Plan (TAP) is a planning document for the FY98-03 S&T program and is based on the President's FY98 Budget Request. It does not reflect the FY98 Congressional appropriations and FY98-03 budget actions that may impact the S&T budget in selected TAPs. You should consult WL/FIIC, (937) 255-4294 for specific impacts that the FY98 appropriation may have with regard to the contents of this particular TAP. This document is current as of 1 April 1997.

Internet access

Electronic copies of the most recent Air Vehicles TAP and other Air Force TAPs are now available on the world wide web (letters are case sensitive): **http://www.afmc.wpafb.af.mil/STBBS**

Additional information concerning this technology area is available on the Flight Dynamics Directorate home page: **http://www.wl.wpafb.af.mil/flight/fihome.htm**

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13. ABSTRACT (Maximum 200 words)

Air vehicle technology spans multiple technical disciplines to provide the Air Force and our nation with innovative solutions to both near and far-term defense needs. Our scientists and researchers work in Integrated Product Terms (IPTs) that design, develop and provide optimum air combat capabilities. The IPTs, the TMP and the Mission Area Plans(MAPs), generated in coordination with the warfighter communities, ensure the emphasis of Research Development Test & Evaluation RDT&E) is focused on the areas of greatest need. Affordability is paramount and is given utmost consideration in all phases of RDT&E within the Air Vehicles Technology Area. During a time of declining budgets and resources, we are challenged to maintain and provide critical technologies, ensuring the nation's superior defense capabilities. We developed a strategic plan for Air Vehicles RDT&E to ensure we can maintain our leadership role, and to build a foundation for continuing excellence into the future.

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AIR VEHICLES

VISIONS AND OPPORTUNITIES

Prelude

Air Vehicles continue to respond decisively to US adversaries with technological advances that ensure our overwhelming military advantage. The Air Force is teaming with the Navy, National Aeronautics and Space Administration (NASA), academia, and industry in a national program to define and develop technologies to meet warfighter capability requirements and address emerging and uncertain threats. These technologies must provide affordable solutions.

Wright Laboratory's Flight Dynamics Directorate (FI) has a legacy of innovative design concepts such as fly-by-wire flight control systems, aeroelastically tailored wings, thrust vectoring nozzles and high angle-of-attack flight among other technologies.

Air Vehicles is achieving superior Science and Technology (S&T) advances by focusing on technologies that extend the AF fleet service life as well as technologies that produce revolutionary advances in military weapon systems. Due to budget constraints the current AF fleet must operate well beyond its initially projected operational life. Therefore, ways to significantly extend fleet life and capability, while reducing cost of ownership, are found through aggressive S&T application. We call this emphasis **TAFT**, Today's Aircraft Flying Tomorrow.

Studies such as the New World Vistas and AF 2025 are incorporated and exploited within Air Vehicles S&T to form the basis of the next generation warfighter capabilities. These new system capabilities will provide the US with air and space superiority into the 21st century. This emphasis is called **FATE**, Future Aircraft Technology Enhancements.

Vision

By the year 2000,

"The Flight Dynamics Directorate will be recognized as the Department of Defense leader in providing the development of military fixed wing air vehicle technologies."

Our vision incorporates **TAFT** and **FATE** areas of emphasis. **TAFT** emphasizes development of near term technologies to extend the AF fleet beyond its original service life. **FATE** emphasizes development of breakthrough technologies for long term revolutionary fixed wing air vehicles. This balanced approach will ensure emphasis on affordability and supportability while encouraging innovative system solutions.

Principal Planning Strategy

The Flight Dynamics Directorate leads the development of several multi-organizational air vehicle S&T strategic planning efforts. One of these efforts is the Fixed Wing Vehicle (FWV) Technology Development Approach (TDA) Integrated Product Team (IPT). This integrated product team consists of the AF, Navy, Defense Advanced Research Projects Agency (DARPA), NASA, academia, and industry. Together they identify cooperative and individual S&T programs that are necessary to achieve fixed wing vehicle goals in three technology driven phases ending in 2003, 2008 and 2013 respectively. The FWV TDA directly supports the new streamlined Defense Technology Area Plan and its associated Defense Technology Objectives (DTOs) as well as the Joint Aeronautical Commanders Group (JACG) Federal Aviation S&T interactive database. A landmark event in 1997 was the stand-up of the national Fixed Wing Vehicle Program. The Flight Dynamics Directorate is also the AF lead in a joint DoD/NASA Advanced Fixed Wing Technology Activities (AFTA) panel which seeks and oversees further collaboration of S&T research resources. These planning processes are thoroughly integrated to ensure a balanced and focused national air vehicle technology investment.

Opportunities

The FWV Program will provide a stabilized framework for which fixed wing air vehicles S&T investments can be identified, prioritized, and executed. It will transition national military fixed wing vehicle goals into warfighter capabilities.

The Air Force Modernization and Planning Process (AFMPP), Mission Area Plans (MAP), and Technology Master Process (TMP) all promote linkage between user needs and S&T research. This cooperation and coordination further helps to focus air vehicles S&T so that the greatest benefits/payoffs are realized. The Flight Dynamics Directorate actively participates and supports these processes.

Summary

Air vehicles technology spans multiple technical disciplines to provide the Air Force and our nation with innovative solutions to both near- and far-term defense needs. Our scientists and researchers work in Integrated Product Teams that design, develop and provide optimum air combat capabilities. It is the cooperation and coordination of these IPTs, consisting of DoD, NASA, academia, and industry that will ensure the emphasis of air vehicles S&T is placed on the highest national defense needs.

During a time of declining budgets and resources, we are challenged to maintain and provide critical technologies, ensuring the nation's superior defense capabilities. Affordability is paramount and is given utmost consideration in all phases of the Air Vehicles Technology Area. We developed and lead a FWV Program for Air Vehicles S&T built around **TAFT** and **FATE** to ensure we can maintain our leadership role, and to build a foundation for continuing excellence into the future.

This plan was reviewed by all Air Force laboratory commanders/directors and reflects integrated Air Force technology planning. I request Air Force Acquisition Executive approval of the plan.

RICHARD W. DAVIS, Colonel, USAF
Commander
Wright Laboratory

RICHARD R. PAUL
Major General, USAF
Technology Executive Officer

CONTENTS

NOTES

INTRODUCTION

Background

The Air Vehicles Technology Area, highlighted in Figure I.1, is part of the Air Force S&T program. The Air Vehicles Technology Area Plan (TAP) identifies how advanced aircraft technology is developed to address solutions to user needs by using the Technology Master Process (TMP) and the Mission Area Plans (MAPs) adopted by HQ Air Force Materiel Command (AFMC) and the user community.

All Air Force aircraft in service today incorporate design criteria and subsystem designs that were developed and validated in the Air Vehicles Technology Area. Within the last ten years Air Vehicle technologies enabled 25-30% composite air frames; provided reductions in development, operations and support costs; provided increases in range, payload and survivability; and enabled the development of existing aircraft such as the B-2, C-17, and Boeing 777. This was accomplished as well as providing enabling technologies for future aircraft, such as the Joint Strike Fighter (JSF), F-22, and Uninhabited Combat Air Vehicles (UCAV). Recent successful accomplishments include:

- Conducted the first supersonic thrust vectored flight on the F-15 ACTIVE aircraft.
- Demonstrated fluidics concepts for exhaust nozzle thrust vector and throat area control with substantial weight reductions.
- Demonstrated applicability of advanced bonded repair of transport fuselage cracks, saving re-skinning costs.
- Flight validation of low horsepower electric actuators on aileron of NASA F-18 in joint USAF, Navy, and NASA program to support ACC's need for increased survivability and decreased maintenance costs.
- Flight demonstrated the Intraformation Positioning System on MH-53J helicopters and MC-130H aircraft to improve close air operations in adverse weather.
- Fabricated the first Titanium Matrix Composite (THC) F-18 nose landing gear drag brace piston.
- Identified brominated alkenes and brominated unsaturated ethers as the most promising halocarbons for Halon 1211 replacement in flight line fire extinguishers.
- Demonstration of integrated voice control in an OV-10 validating in-flight cockpit operations under high "G" and high ambient noise levels.

These accomplishments are also directly tied to warfighter needs through the Technology Planning Integrated Product Team (TPIPT) and the MAPs process. The users and their specific needs are outlined within our Thrust writeups.

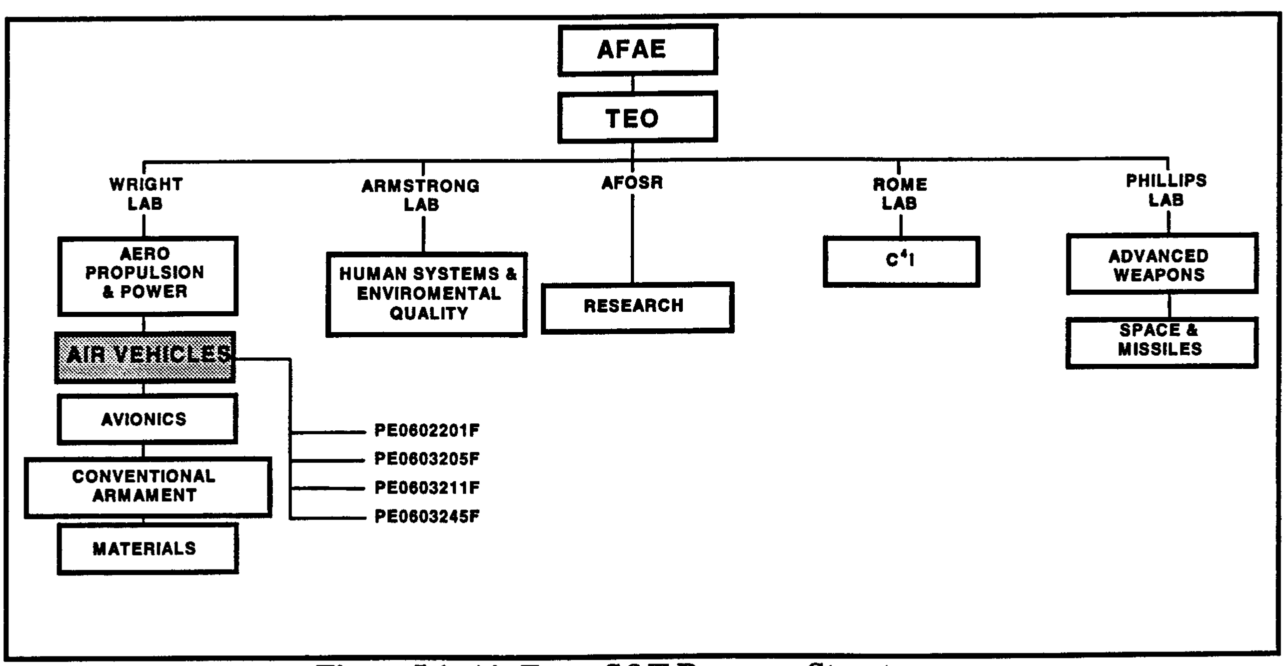


Figure I.1: Air Force S&T Program Structure

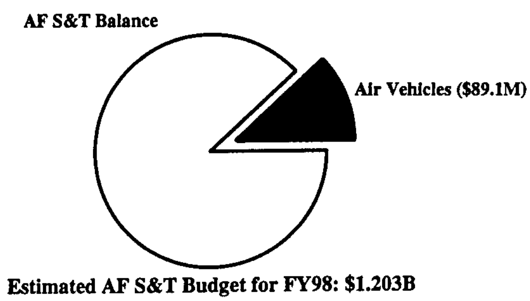
Air Vehicles technology users include the Aeronautical Systems Center (ASC), which manages the development and fielding of new aircraft and armament systems; AFMC and the Major Commands (MAJCOM), which develop, process, use, maintain and upgrade the existing air and space forces from "cradle to grave"; the aerospace industry, which develops, designs and manufactures military and commercial aerospace vehicle systems; and the Army, Navy, Marines, Coast Guard and Federal Aviation Administration (FAA) , which rely on the Air Force for development/demonstration of Fixed Wing Air Vehicles technologies. The Air Vehicles Technology Area is the Tri-Service Lead for Fixed Wing Aircraft in Integration Technology, Aeromechanics, Structures, Flight Control, Vehicle-Pilot Integration, Vehicle Subsystems and Air Base Technology. These technologies are mirrored in the Air Vehicles Thrust titles shown in Table I.1.

Table I.1: Major Technology Thrusts
1. INTEGRATION TECHNOLOGY
2. AEROMECHANICS
3. STRUCTURES
4. FLIGHT CONTROL
5. VEHICLE-PILOT INTEGRATION
6. VEHICLE SUBSYSTEMS
7. AIR BASE TECHNOLOGY

Air Vehicles S&T Funding

The funding to achieve the required Air Vehicles research is shown in Figure I.2, and reflects the Air Vehicles technology area share (7% in FY98) of the AF S&T budget. All funding is based on the President's FY98 Budget Request and is subject to change based on possible congressional action.

Figure I.2: Air Vehicles S&T $ vs Air Force S&T $



The Air Vehicles Thrust Areas funding breakdown is shown in Figure I.3.

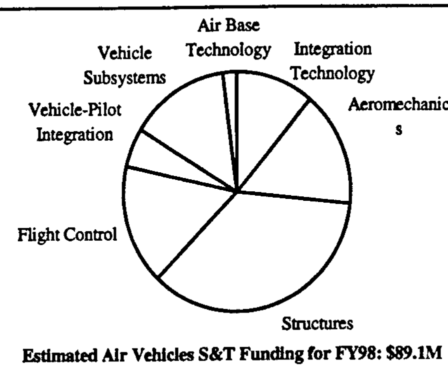


Figure I.3: Major Technology Area $

Relationship to Other Technology Areas

Air Vehicles Thrusts have relationships with our allies through Data/Information Exchange Agreements (DEAs/IEAs), and Memoranda of Understandings/Agreements (MOUs/MOAs). We have over 30 DEAs/IEAs with foreign countries to conduct research and development in basic technologies such as computational fluid dynamics, airframe weapons integration, aerothermodynamics optimization, aeroelasticity analysis methods, life prediction techniques for high-temperature structures, high angle-of-attack (AOA) flight stability and control, flight control techniques, structural integrity, robust coatings and epoxy transparency repair, among others.

We have MOUs with the Air Force, Army, Navy, and NASA in subsystems and display technologies research, as well as working relationships with DARPA on the congressionally directed High Definition Systems program. Specifically, we have MOAs with the FAA and NASA Langley to explore aging aircraft technology.

The Integration Technology Thrust has a joint program, Extended Range Demo, with NASA Dryden that will develop and flight demonstrate the use of thrust vectoring for increasing cruise range and reducing drag during "high g" maneuvers. Emphasis will be placed on using the vectoring nozzle for pitch and yaw trim while moving the aerodynamic controls to a low drag streamlined position.

The Aeromechanics Thrust works closely with the Navy and DARPA to provide affordable performance improvements for future fighter aircraft. Joint efforts are being accomplished with NASA to develop maneuverable extended range configurations for advanced low signature fighters and transports. Rapid aerospace vehicle assessment and optimization codes are being developed, with close collaboration between NASA, AFOSR and Wright Laboratory scientists, to maximize the payoff from each agency's investment. The Aeromechanics Thrust provides technical support to ASC in the application of Computational Fluid Dynamics (CFD) methods for solutions to flight problems encountered by today's operational aircraft. Multibody CFD methods are being developed for certification of stores carriage and release. Aeromechanics programs in nozzle and inlet integration technology are accomplished as a team with the Aero Propulsion and Power Directorate to increase performance, reduce weight and reduce signature.

The Structures Thrust has a joint effort with the Naval Air Warfare Center to explore structural health monitoring of the Air Force and Navy aircraft and significant improvements to the aircraft structural integrity programs. A cooperative program with NASA Langley is testing the buffet alleviation approaches on a 16% model of the F-18 tail. A collaborative in-house effort with the Aeromechanics Thrust and Flight Control Thrust is underway to control buffet on twin-tail fighter aircraft at high angle of attack. Integrated Process Teams were developed with the Aeromechanics and Flight Controls subthrusts to develop and demonstrate multidisciplinary design and analysis methods and active aeroelastic wing technologies. Research jointly funded with the FAA is being conducted to account for the effects of corrosion and multiple site damage in structural risk analysis. An MOU with NASA and FAA is covering aging aircraft work in corrosion fatigue, widespread fatigue damage, and repairs. A jointly funded program with Phillips Lab and NASA is developing thermal protection systems, cryogenic tanks, and composite primary structures for reusable launch vehicles. A program is underway with NASA Langley, Georgia Tech and Lockheed on modification and verification of our flagship computer program, ENS3DAE, for analyzing the computational fluid dynamics of aeroelasticity. Collaborative efforts are also in place with the Materials and Processes Thrust in the following areas: composites affordability; advanced high temperature exhaust materials; high temperature thermal protection systems; composite structures and cryogenic tank materials for reusable launch systems; adhesive bonding and joining; and aging aircraft sustainment.

The Flight Control Thrust is the national leader in the development of a comprehensive approach to eliminating catastrophic Pilot-Induced Oscillations (PIO), working closely with the major ASC System Program Offices and interacting with aircraft manufacturers and the National Research Council's Committee on Aircraft-Pilot Coupling. The Flight Control Thrust is working closely with the Aeromechanics Thrust, NASA, and the Navy to provide higher fidelity modeling of agile aircraft through better estimation of dynamic stability and control parameters. In a joint critical experiment with NASA and the Navy, the Flight Control Thrust is flight validating electrical actuation designs for primary control surfaces of high performance military aircraft. Closely related are the Thrust's role as agent for the DARPA sponsored Electric Actuation and Control System II Technology Reinvestment Program (TRP) developing a "flight ready" electric actuator for the F/A-18 stabilator, the cooperative work with the Aerospace Propulsion and Power Directorate to develop flight control technology required for the More Electric Aircraft, and collaborative efforts with the Structures Thrust to develop advanced flight control techniques and actuation devices to enable the control of aeroelastic wings and other innovative structure designs. Another DARPA sponsored program, where the Flight Control Thrust is agent, is the Laser Wind and Hazard Profiler program that will improve the ability to measure flight vehicle air data and wind conditions for weapon delivery. The Flight Control Thrust is the Government team leader for the DARPA sponsored consortium developing an Autonomous Landing Guidance System for all weather operations. This thrust is also investigating the survivability of flight control systems. Programs are being developed identifying threats and survivability enhancements to military flight control equipment for the Joint Technical Coordination Group for Aircraft Survivability. The U.S. Special Operations Command (USSOCOM) sponsored Intraformation Positioning System program develops technology that provides flight management, control, and deconfliction during ingress, egress, rendezvous, formation, and terminal area operations. The Air Force Office of Scientific Research (AFOSR) sponsors Flight Control Thrust research in multivariable control theory to develop and mature new design methods and flight control algorithms. AFOSR also sponsors research in Air Vehicles targeted at developing better aerodynamic modeling and control techniques for global range transports. Finally, the Flight Control Thrust has a cooperative effort with the Navy to study the causes of spatial disorientation and the effect it has on piloted aircraft control.

The Vehicle-Pilot Integration thrust is interdirectorate, comprised of the Vehicle-Pilot Integration Branch in the Flight Dynamics Directorate, and the Display Avionics Branch in the Avionics Directorate. These two branches are responsible for two subthrusts: Crewstation Integration and Demonstration, and Advanced Display Developments. In-house research within the Crewstation Integration and Demonstration subthrust includes the Tactical Information Dominance (TACID) program that focuses on a capability for enhanced pilot situational awareness through effective crew management of real-time, off-board information. TACID will integrate display technology with emerging sensor fusion methods, inflight route planning, and human-computer interface technologies to enable aircrew exploitation of real-time information to attack time-critical targets. This subthrust also has the Cockpit Voice Integration program that demonstrates, in ground based simulation and in flight, voice control of cockpit functions to reduce crew workload and enhance weapon system effectiveness. The Combat Flight Management (CFM) Advanced Development program, also in the Crewstation Integration and Demonstration subthrust, will automate selected piloting functions, including in-flight route planning and flight control and integrate these functions with advanced cockpit controls and displays. Modular software will be developed to provide affordable low risk transition to multiple platforms. The system will be demonstrated and evaluated in piloted F-16 simulations to confirm system maturity. A program in Primary Flight Display Integration is also found in this subthrust, working to integrate symbology with advanced flight guidance, weapon and sensor technologies. The Vehicle-Pilot Integration Thrust is also pursuing collaborative efforts with the Flight Control Thrust in the area of UCAV, to assure optimum control through the proper blend of automation and operator "hands-on" intervention. This is a new endeavor and is directly responsive to the recommendations in the Scientific Advisory Board's (SAB) New World Vistas report. The Vehicle-Pilot Integration Thrust's Advanced Display Development subthrust continues to develop and mature cockpit avionics systems, including electronic displays and graphics processors, providing an exceptionally effective process for coordinating integration requirements and display hardware design criteria. Research in this thrust is closely coordinated with the Joint Cockpit Office and the Armstrong Laboratory and maintains the robust and complementary cockpit integration development program that has been established between these organizations and the Army and Navy.

The Vehicle Subsystems Thrust has two MOUs with NASA Langley Research Center (LaRC) on the Radial and Bias Aircraft Tire Testing and the Improved Tire Life programs. NASA LaRC supplies facilities and manpower, and the Air Force supplies hardware, data and manpower. The Vehicle Subsystems Thrust has an MOU with the FAA to conduct research aimed at providing hardening techniques to increase the survivability of transport aircraft. The FAA provides 100% funding, while the Air Force supplies test facilities, manpower, test articles and data. This Thrust is working closely with Armstrong Laboratory within the technology area of crew escape to expand the performance envelope of ejection systems. The Vehicle Subsystems and Air Base Technology Thrusts are also working closely with other services and the FAA to explore options for replacing banned ozone depleting substances such as Halon.

Changes From Last Year

The Air Vehicles Technology Area – except Vehicle-Pilot Integration and Air Base Technology – is aligned with the DoD Technology Area Plan (DTAP) for Air Platforms as supported by the Fixed Wing Vehicle Technology Development Approach. The Air Platforms Technology Area is the integration lead for DoD Fixed Wing Air Vehicles.

The Civil Engineering and Environmental Quality Technology Area Plan was eliminated. The Civil Engineering portion, renamed Air Base Technology, is now a thrust of the Air Vehicles Technology Area Plan.

The Vehicle-Pilot Integration Thrust participated in extensive discussions with Armstrong Laboratory and Joint Cockpit Office personnel to better focus respective roles and missions in order to produce a single, integrated USAF S&T vision for investments in the cockpit/crew station area.

These deliberations clarified the Vehicle-Pilot Integration Thrust's responsibilities and established it as lead for research to implement vehicle-pilot interfaces that integrate the hardware and software technologies for which Wright Laboratory has the lead.

The Thrust was also established as the lead for the Crew Station Integration Demonstrations DTO, under the Design Integration and Supportability subarea within the Human Systems DTAP.

FI has initiated a joint aircraft conceptual design standard with academia, industry and government agencies. The central focus is on multi-disciplinary designs, and the goal is to develop an integrated design as a conceptual design baseline.

The Air Vehicles Thrusts are responding to the Air Force's new emphasis in UCAV and other air vehicle configurations, as recommended by the SAB's New World Vistas Study.

THRUST 1: INTEGRATION TECHNOLOGY

User Needs

The Integration Technology Thrust provides technology solutions to a variety of user needs as stated in the MAPs, Mission Need Statements, Operational Requirement Documents and user-proposed Advanced Technology Demonstration programs. Many of these deficiencies evolved from operational user needs through strategies-to-task analyses. The users for Integration Technology include Air Combat Command (ACC), Air Mobility Command (AMC), Air Force Special Operations Command (AFSOC), Air Education and Training Command (AETC), AFMC, Aeronautical Systems Center (ASC), major System Program Offices, other government agencies such as National Air Intelligence Center, commercial industries and universities.

The programs in this thrust were derived to solve the following user-documented needs:

- ACC requirements for quick reaction; increased range, maneuverability, and payload; low observable weapon carriage; smart weapon support; controlled-flight departure prevention; enhanced survivability; high AOA simulation testbed; and affordable technologies for the 21st century.
- AMC requirements for improved cockpit commonality, reliability and maintainability; real-time information to aircrews; and all-weather intraformation station keeping capability.
- AFMC requirements to support the Air Force Test Pilot School and to provide quick reaction support to the major weapon Systems Centers and Logistics Centers in the areas of control hardware and software, aeromechanics, structures, subsystems and cockpit avionics.
- AFSOC requirements for improved thermal energy management systems, night/in-weather covert intraformation collision avoidance.

Goals

The Integration Technology Thrust goals are twofold. The first is to demonstrate the accomplishment of the FWV goal set at the conclusion of each phase.

The Integration Technology Thrust will demonstrate the following objectives by the year 2008 (Figure IT-1):

I. 20% Reduction (RED) in production cost for the first production aircraft (T1)
II. 20% RED in reduced operations and support costs
III. 20% RED in engineering and manufacturing development (EMD) cost
IV. 20% RED in airframe weight
V. 10% Increase (INC) in cruise lift/drag
VI. 20% INC in agility-maneuverability (manned/unmanned)
VII. INC in cargo delivery accuracy
VIII. INC in max trimmed C_L at takeoff and landing

The second is to develop technology to improve the capability of designers and technology managers to predict the benefits of individual technologies and significantly reduce the design, demonstration, and system integration cycle time. The Integration Technology Thrust, in concert with the Office of the Director for Defense Research and Engineering (ODDR&E) has aligned a demonstration program to conclusively demonstrate the accomplishment of the sub-area goals of the Fixed Wing Vehicle Program as defined in the DTAP for Air Platforms.

Major Accomplishments

- Conducted the first supersonic thrust vectored flight on the F-15 ACTIVE aircraft.
- Completed modification of the VISTA NF-16 for Programmable Helmet Mounted Sight.
- Led the establishment of the Fixed Wing Vehicle Program. This National program works concurrently to meet the sub-area goals through teaming and integration at all levels of technology development.
- Established contractual means for early analysis of required technologies on the FATE 1 demonstrator vehicle.

INTEGRATION TECHNOLOGY THRUST

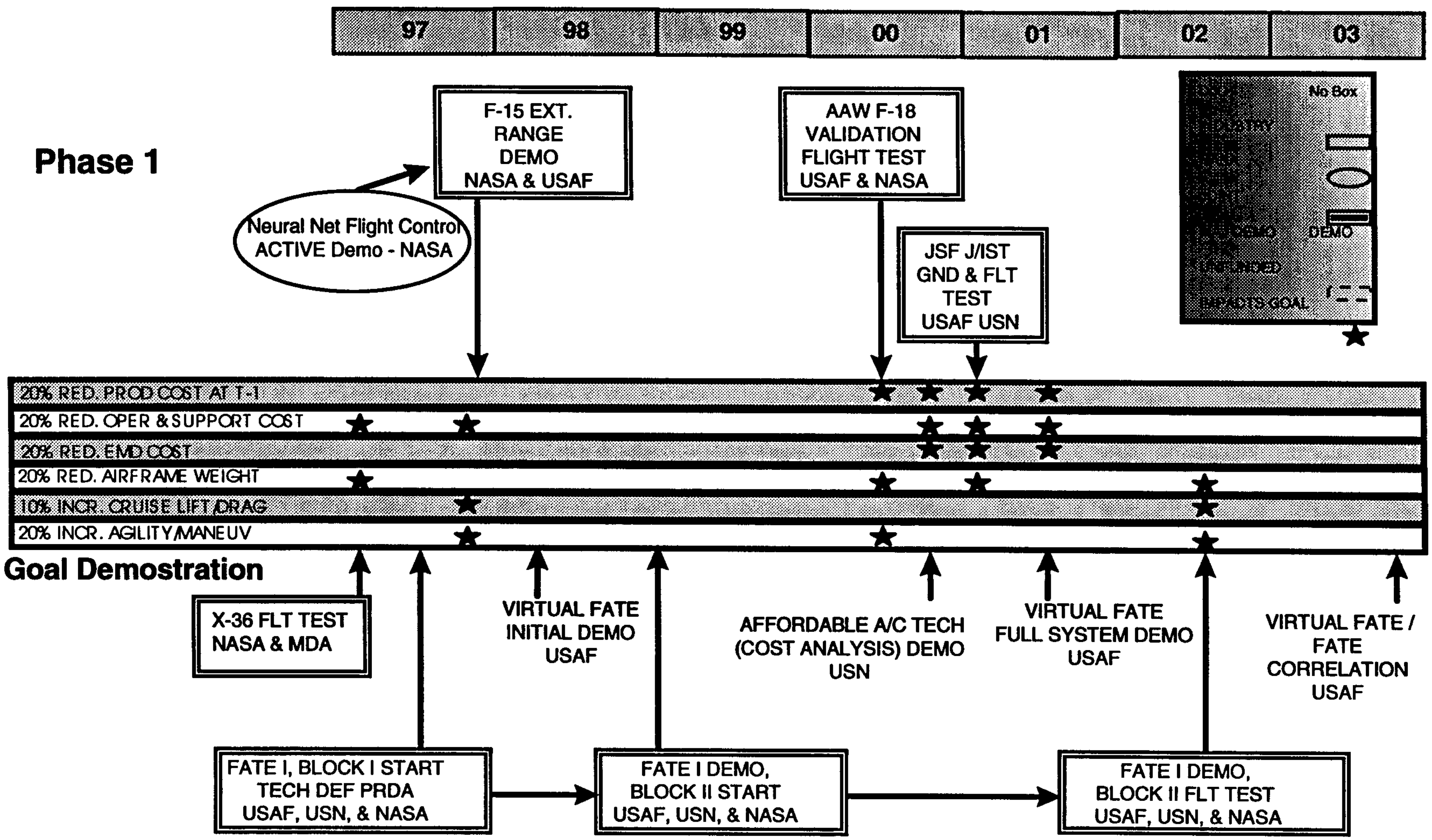


Figure IT-1

Changes from Last Year

The Air Combat Supremacy Program was deleted from the integration thrust to better align the demonstration strategy with the FWV Program goals. The Advanced Concepts Core area was consolidated under the Virtual FATE.

Milestones

The milestones, outlined in Figure IT-1, are grouped in their respective subthrust area. The following milestones further expand the Goals section into specific quantifiable events by fiscal year.

Advanced Development

VISTA Upgrade:

FY97: Complete the engine conversion, hydraulic system changes, and other hardware modifications needed to support installation of a thrust vectoring nozzle, and complete all installation, ground and flight checkout of the programmable display system.

FY98: Develop a specialized Aircraft Structural Integrity Program (ASIP) unique to VISTA to predict structural inspection requirements based on the peculiar loads/fatigue spectrum that are experienced due to variable stability flight operations with thrust vectoring.

FY98: Upgrade the computer system to permit simultaneous use of the thrust vectoring capability with the variable stability system.

FATE:

FY99: Initiate design and analysis of the FATE concept.

FY00: Complete preliminary concept design and technology trade studies for FATE.

FY01: Flight demonstrate Active Aeroelastic Wing. This will realize a reduction in maneuvering wing weight, cruise/maneuver drag and hinged control surfaces; providing control authority for tail-less configurations.

FY02: Initiate flight testing of the FATE-1 Demonstration Vehicle. This vehicle will substantiate the FWV Program goals for 20% reduced airframe weight, 10% increased cruise lift to drag, and 20% increased agility-maneuverability.

Extended Range Demo:

FY97: Obtain cruise range optimization by utilizing thrust vectoring to produce the pitch normally obtained by the tail. This is the first step toward reducing the drag and/or rudder size.

Advanced Concepts

Technology Development Approach:

FY97: Government and Industry FWV TDA constructed a representation of the national FWV 15-year plan in terms of payoffs, goals and technical effort objectives in 5-year increments. The integrated product team "stood-up" the Fixed Wing program.

FY97: Substantiate the Technology Effort Objectives (TEO) meet the subarea goals.

FY98: Validate FWV Program cost goals to show affordability impacts of advanced S&T.

Virtual FATE:

FY97: Proof of concept Conceptual Aircraft System Design Analysis Toolkit (CASDAT) demonstration of state-of-the-art modular software architecture with interchangeable modules and user-friendly designer interface.

FY98: Integrated architecture for development of virtual design environment utilizing initial operational capability of CASDAT system. Initial inclusion of multidisciplinary modules to design and analyze revolutionary FWV concepts.

FY99: Initial functional capability of synthetic design environment using full capability of CASDAT to analyze a revolutionary aircraft configuration.

FY01: Synthetic analysis capability for selected sets of multidisciplinary optimization of technology concepts. Includes verification and full life cycle predictions of cost and effectiveness implications.

FY02/03: Validation and accreditation of design environment through cross check with flight-validated performance results from FWV Demonstration Program Phase I.

THRUST 2: AEROMECHANICS

User Needs

Advanced aeromechanics technologies yield extended range, enhanced maneuverability, and increased payload, while enhancing affordability, maintainability, and stealth. Substantial gains in military aircraft performance and reduced design complexity are realized by radically new configuration concepts.

The warfighters' needs addressed in this thrust have been identified in their MAP documents and the needs developed in the TPIPT forum:

- ACC's Counter Air requirements for improved range, maneuverability, and acceleration.
- ACC's Close Air Support/Interdiction requirements for reducing the range penalty for carrying external stores and developing the technology to provide a standoff fast reaction weapon.
- AFSOC's need for air vehicle technology to support planning for replacement of aging transport aircraft and to identify new aircraft with Vertical/Short Take Off/Landing (VSTOL) capabilities.
- Air Force Space Command's (AFSPC) Spacelift requirement to plan for replacement of the Space Shuttle in the next century.
- ASC System Program Office's (SPO) technology needs for modern day aircraft, such as F-117, F-22, B-2, C-17 and technology for emerging concepts, such as the JSF.

Goals

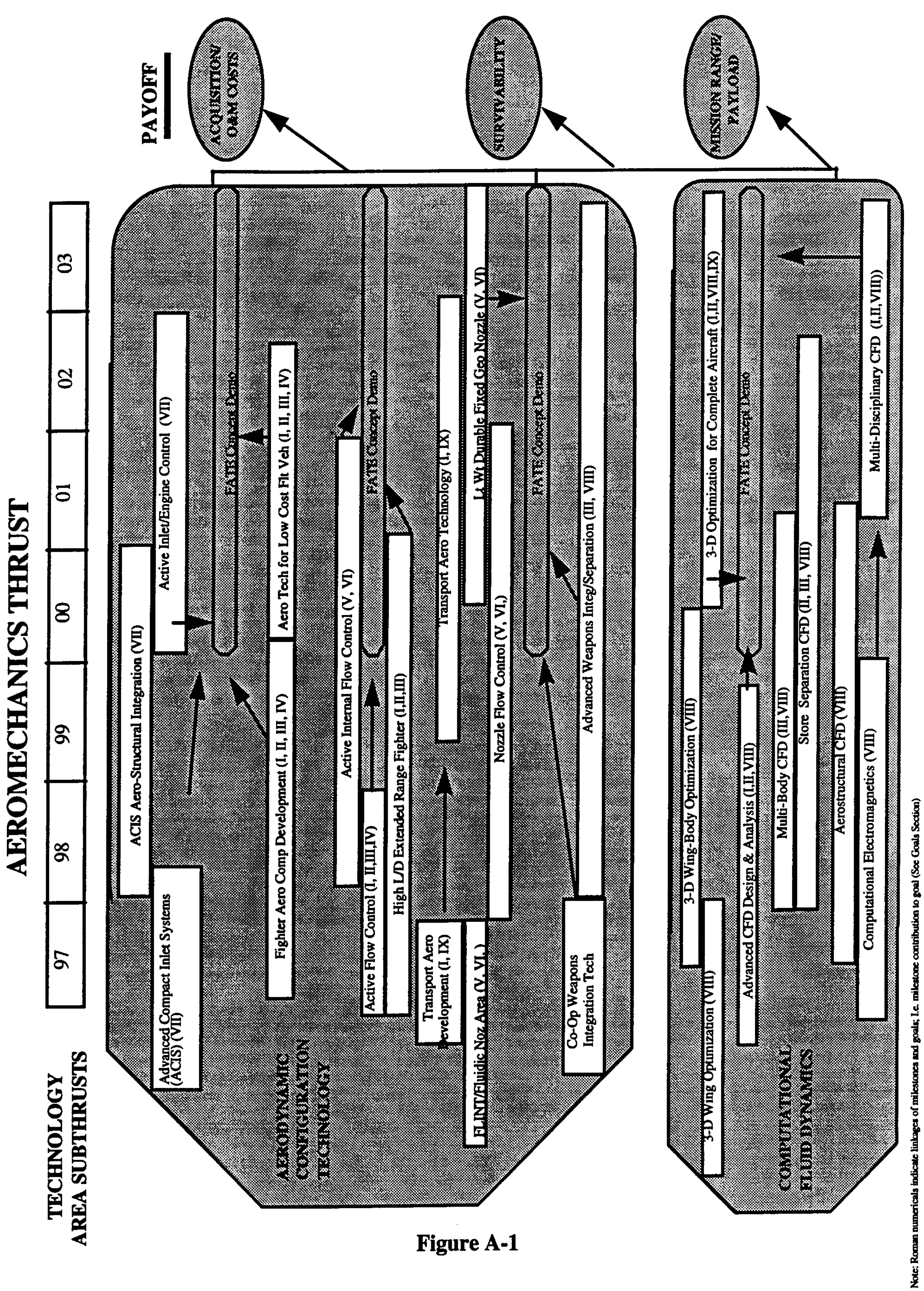
The goals of the Aeromechanics thrust are grouped into technical subthrusts of Aerodynamic Configuration Technology and CFD to support future air vehicle goals. (See Figure A-1). The Aeromechanics Thrust will achieve the following representative technology effort objectives by the year 2008, the end of Phase II of the Fixed Wing Vehicle Technology Development Approach:

I. 12% RED in cruise drag
II. 15% INC in maneuvering lift/drag
III. 35% INC on payload range with weapons
IV. 25% INC in landing approach lift coefficient
V. 35% RED in nozzle weight
VI. 35% RED in nozzle acquisition costs
VII. 50% RED in inlet weight and volume
VIII. 60% RED in aerodynamics design cycle time
IX. 12% RED in take-off distance

These goals are fully aligned with the DTO in the DTAP for Air Platforms.

Major Accomplishments

- Validated, in cooperative wind tunnel tests with NASA, transonic and supersonic performance of bifurcated and front frame integrated advanced compact inlets.
- Demonstrated fluidics concepts for exhaust nozzle thrust vector and throat area control, with a substantial reduction in weight.
- Determined, in wind tunnel tests demonstrating active acoustic suppression, store separation environment in weapons bays.
- Demonstrated, on engine ground test, plume temperature and acoustics reduction using fluidic active flow control.
- Experimentally investigated high-lift aerodynamic concepts to reduce take-off distances for affordable, survivable transport aircraft.
- Validated subsonic and transonic performance of low-drag/ low observable aerodynamic weapons carriage concepts to increase weapons payload and air vehicle range and survivability.
- Completed wing-fixed body design optimization capability for multi-point aerodynamic objectives such as lift, drag or pitching moment using advanced computational fluid dynamic methods.
- Installed, in partnership with the Flight Control Thrust, a multi-axis spin and oscillatory motion test rig in Wright Laboratory's Vertical Wind Tunnel. Provides DoD the unique capability to measure non-linear static and dynamic stability attributes of advanced air vehicle configurations.
- Completed development and demonstration of a one Megahertz frame rate camera used in investigations of high speed aerodynamics.
- Developed an improved engineering prediction of complex aircraft viscous flows, including leading edge vortices, vortex breakdown, and shock/ boundary layer interactions. New capabilities were immediately transitioned to high angle -of-attack F-22 large scale simulations.
- Successfully implemented a first-ever high-order compact solver on curvilinear grids for the time-domain electromagnetic equations. This new approach will extend frequency range and fidelity of radar signature predictions.


AEROMECHANICS THRUST
TECHNOLOGY AREA SUBTHRUSTS
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PAYOFF
ACQUISITION/ O&M COSTS
SURVIVABILITY
MISSION RANGE/ PAYLOAD
AERODYNAMIC CONFIGURATION TECHNOLOGY
Advanced Compact Inlet Systems (ACIS) (VII)
ACIS Aero-Structural Integration (VII)
Active Inlet/Engine Control (VII)
FATE Concept Demo
Fighter Aero Comp Development (I, II, III, IV)
Aero Tech for Low Cost Flt Veh (I, II, III, IV)
Active Internal Flow Control (V, VI)
Active Flow Control (I, II,III,IV)
High L/D Extended Range Fighter (I,II,III)
FATE Concept Demo
Transport Aero Development (I, IX)
Transport Aero Technology (I, IX)
FLINT/Fluidic Noz Area (V, VI,)
Lt Wt Durable Fixed Geo Nozzle (V, VI)
Nozzle Flow Control (V, VI,)
FATE Concept Demo
Co-Op Weapons Integration Tech
Advanced Weapons Integ/Separation (III, VIII)
COMPUTATIONAL FLUID DYNAMICS
3-D Wing Optimization (VIII)
3-D Wing-Body Optimization (VIII)
3-D Optimization for Complete Aircraft (I,II,VIII,IX)
Advanced CFD Design & Analysis (I,II,VIII)
FATE Concept Demo
Multi-Body CFD (III,VIII)
Store Separation CFD (II, III, VIII)
Aerostructural CFD (VIII)
Computational Electromagnetics (VIII)
Multi-Disciplinary CFD (I,II,VIII)
Note: Roman numericals indicate linkages of milestones and goals; i.e. milestone contribution to goal (See Goals Section)

Figure A-1

Changes from Last Year

The Aeromechanics Thrust now is completely aligned with the Air Force Modernization Planning Process (AFMPP) linking laboratory technology efforts and MAJCOM deficiencies and with DDR&E's FWV TDA. The FWV TDA is the national program planning research for fixed wing vehicles using DoD, NASA and industry resources. In the AFMPP, MAJCOM needs were revised and are reflected in our strategic planning as depicted in the Roadmaps of Annex B. The Technology Effort Objectives of the FWV TDA were revised and are listed above and also reflected in our strategic planning. The objectives of both these important strategic planning tools are met in the Aeromechanics Thrust simultaneously.

Milestones

The programs outlined in Figure A-1 are grouped in their respective subthrust area. The following program milestones further expand the Goals section into specific quantifiable events.

Aerodynamic Configuration Technology

FY98: Complete development of high-payoff aerodynamic concepts that significantly extend combat aircraft mission range.

FY98: Validate high payoff payload/range technologies in tests of extended range fighter configurations.

FY98: Demonstrate effectiveness in subscale tests of pulsed injection in fluidic thrust vectoring. Technology supports goals of reduced nozzle weight and acquisition costs.

FY98: Complete analysis and design methods for reducing aeroacoustic damage in aircraft twin nozzle installations to increase nozzle life.

FY98: Demonstrate and quantify active control. skin friction drag reduction in critical experiments.

FY99: Develop inlet hammershock loads and structures integration criteria for application to air vehicles with extremely high thrust-to-weight ratios. Demonstrate improved hammershock load specification in diffuser rig test.

FY99: Complete design of variable geometry, continuous moldline, external fuel tank concepts to extend fighter mission range.

FY00: Complete design application of pneumatic flow control devices for highly survivable fighter aircraft.

FY00: Develop a microelectromechanical device application for active control of boundary layer transition and separation, achieving high lift and low drag with minimum energy addition.

FY01: Complete experimental database for extended range aircraft technology demonstrator incorporating configuration elements meeting requirements of minimum weight composite structure.

FY01: Demonstrate large scale, fixed exit, variable throat, afterburning, highly survivable nozzle.

FY02: Demonstrate large scale transport application of microelectromechanical devices supporting cruise drag reduction for global transports.

FY02: Complete validation of fast, accurate tools for aircraft/ stores compatibility for preliminary design through flight test.

Computational Fluid Dynamics

FY98: Evaluate a prototype executive computerized method to control four different processes on four different computers and accurately share data between them. Supports the 60% reduction in aerodynamic cycle time technology objective.

FY99: Extend wing-fixed-body design optimization capability to tailless configurations featuring variable wing-body/fixed inlet configurations.

FY99: Develop and validate a flow simulation technique to include space- and time-dependent solutions of combined steady and unsteady aerodynamic/structural phenomena.

FY99: Develop and validate an improved simulation of turbulence effects for aircraft buffet, aeroacoustics and flow control with the implementation of large eddy simulation approaches into an implicit flow solver.

FY00: Complete development and validation of scaleable concurrent CFD and Computational Electromagnetics (CEM) codes to achieve one to two orders of magnitude reduction in simulation clock time.

FY00: Accomplish a "first principles" solution of Maxwell's equations to predict the radar signature of an operational aircraft.

FY00: Develop and validate efficient unstructured moving and adaptive grid technologies into a widely used, commercially available, previously structured grid flow solver.

FY02: Evaluate a prototype multidisciplinary CFD/ flight control simulation capability to predict static and dynamic stability derivatives of fighter configurations.

FY03: Combine computational electromagnetic analysis with computational aerodynamic design optimization methods to produce rapid solutions for survivable fighter concepts.

THRUST 3: STRUCTURES

User Needs

The Structures Thrust supports the Air Force need for higher performance, longer life, and more affordable and survivable aircraft structures. New structural concepts and design techniques will exploit the latest materials, processes, and manufacturing technologies to produce more durable structures at lower weight and cost, "smart" structures that counteract fatigue and enhance maneuver capabilities, and high-temperature structures for extreme environment flight. MAP needs addressed are:

- ACC needs improved range, higher readiness, increased performance and survivability, lower buffet vibration, and increased weapons accuracy, all at lower cost.
- AMC needs improved field repairs, longer airframe lifetimes, and greater reliability with fewer inspections. AMC also needs improved aircraft economic service life, despite the effects of fatigue and corrosion.
- AFSOC needs higher reliability, combat availability, and lower vehicle signatures in short takeoff and landing operations on unprepared landing sites.
- AETC needs much more reliable airframes, with lifetimes as long as 100 years.
- AFSPC needs weight-optimized structures for both the expendable and reusable spacelift systems.

Goals

The Structures Thrust goals are grouped into the following technology subthrust areas: Ensure Structural Integrity of Aging Aircraft, Integrate Structural Design, Develop Extreme Environment Structures, and Develop Smart Structures (See Figure S-1). Some of the more specific goals for this thrust include:

I. Reduce overall production costs at T-1 by reducing manufacturing costs of fighter aircraft structure by 35% and assembly costs of all aircraft by 40% by the year 2008.

II. Reduce structural weight of fighter aircraft designs by 30% and airlift/bomber aircraft by 20% by the year 2008.

III. Reduce operational and maintenance costs by extending the fatigue life of fighter aircraft by 35% and airlift/bomber aircraft by 25% by the year 2008.

IV. Reduce support costs of all aircraft types by at least 25%, and special operations forces aircraft by 45% by the year 2008.

V. Reduce EMD costs by reducing airframe development time by at least 25% by the year 2008.

These goals are fully aligned with the DTO in the DTAP for Air Platforms.

Major Accomplishments

- Demonstrated applicability of advanced bonded repair of transport fuselage cracks, saving \$380M in re-skinning costs.
- Demonstrated use of integrated sensors in structural integrity monitoring of bulkhead.
- Validated redesigned T-38 66% wing spar to extend structural life and reduce support costs.
- Demonstrated field-level maintenance of elevated temperature LO repairs to F-117 aft deck.
- Completed thermal erosion tests of a ceramic matrix composite nozzle for longer-life exhaust-washed structures - exceeded predicted performance and demonstrated feasibility.
- Completed development and test of an adhesively bonded composite fighter wing for 15% design time reduction and 50% fabrication cost savings.
- Demonstrated manufacturing viability of bonded composites employing rod-reinforced longerons and preform reinforced bulkheads for significant cost reduction in fabrication.
- Completed integration of a 3-dimensional linear panel code and generalized trim optimization module into the widely-used Automated Structural Optimization System (ASTROS) computer code.
- Completed tests of a powder metallurgy elevated temperature aluminum fighter keel beam shear panel for 10% lower weight and infinite thermoacoustic fatigue life.
- Validated through wind tunnel testing stiffness-on-demand approaches to adaptive structures for reduced weight and enhanced performance.
- Completed first wind tunnel entry of smart, adaptive wing for enhanced maneuverability and LO characteristics and reduced weight.

Changes from Last Year

The DTAP for Air Vehicles was extensively revised, in conjunction with Navy, Army, and

STRUCTURES TECHNOLOGY EFFORT ROADMAP
PHASE I

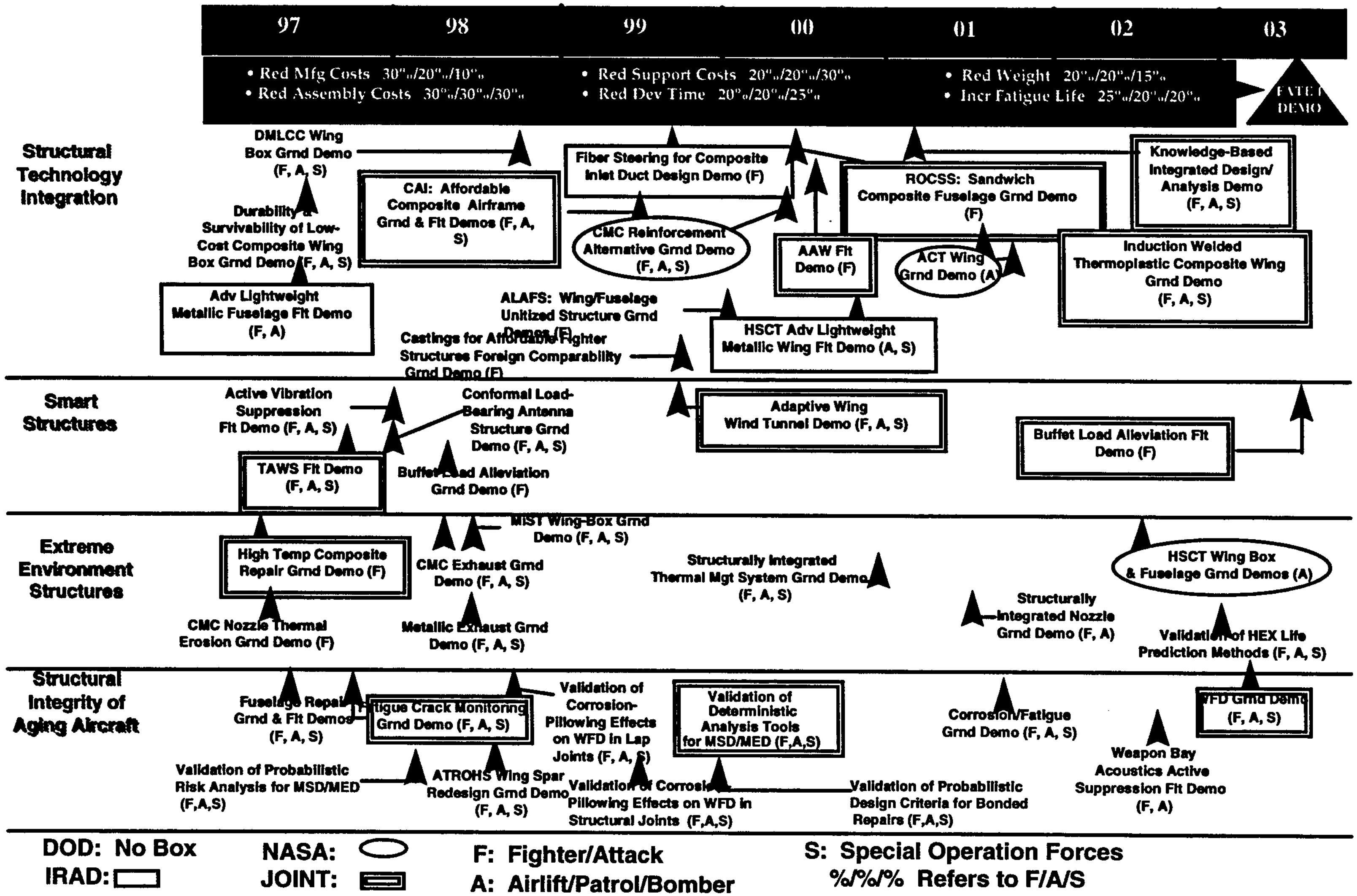


Figure S-1

industry. Revised structures objectives are reflected here.

Major funding cuts were taken in the 6.3 program areas, canceling some work and extending completion dates for other work.

Milestones

The milestones, outlined in Figure S-1, are grouped in their respective subthrust areas. These milestones further expand the Goals section into more specific quantifiable goals by fiscal year.

Ensure Structural Integrity of Aging Aircraft

FY97: Develop active suppression system for weapons bay acoustics to reduce vibration and increase the envelope and combat effectiveness of ACC aircraft.

FY98: Transition to AETC T-38 66% spar redesigned for service durability.

FY98: Develop computational aeroelasticity code for accurate prediction of structures/ aerodynamics interaction.

FY99: Develop life analysis methodology for joints pillowed by corrosion.

FY00: Validate design/analysis tools for repairs.

FY01: Complete corrosion/fatigue demo.

FY02: Complete weapons bay acoustic suppression flight demonstration.

FY03: Validate analysis tools for life/risk analysis to account for the effects of multiple site damage and corrosion fatigue interaction to provide AMC and AETC with longer-life airframes.

Integrate Structural Design

FY97: Characterize critical sandwich panel and textile joint performance for low-weight, low-cost unitized structure.

FY98: Scale-up and test decoupled survivable composite wing box design for reduced weight/cost.

FY98: Complete structural durability tests of low-cost rod-reinforced bonded composite wing box to reduce acquisition cost of V-22 by 15%.

FY98: Begin wind tunnel testing of variable mold line structure for improved drag and signature.

FY99: Flight test Composites Affordability Initiative composite airframe to demonstrate 50% reduction in fighter aircraft acquisition costs.

FY99: Demonstrate affordable Russian casting technology for fighter structures.

FY00: Complete structural test of Advanced Light-Weight Aircraft Fuselage Structures (ALAFS) wing/fuselage articles for 40% increase in composites utilization and 25% reduction in TOGW.

FY01: Complete flight demonstration of Active Aeroelastic Wing concept, demonstrating 6% to 18% reduction in fighter aircraft gross weight.

Develop Extreme Environment Structures

FY98: Demonstrate LO-compatible Ceramic Matrix Composite (CMC) exhaust-washed structure subcomponent durability.

FY98: Demonstrate AFR700B-to-CMC and CMC-to-CMC bolted and bonded joint durability.

FY98: Demonstrate feasibility of design concept for a structurally integrated thermal management system employing CMC exhaust-washed structure.

FY98: Demonstrate metallic exhaust-washed floating deck concept to increase life by 15%.

FY00: Demonstrate structurally integrated thermal management system.

FY01: Demonstrate structurally integrated airframe/nozzle.

FY03: Demonstrate hot structure and TPS concepts for military spaceplane applications.

FY03: Demonstrate heat exchanger concepts for military spaceplane applications.

Develop Smart Structures

FY97: Complete world's first primary structure flight test of piezoelectric vibration suppression.

FY97: Complete strength, durability, and performance tests on conformal load-bearing antenna structure for improved performance at reduced cost.

FY97: Flight test Twist-Adaptive Wing System on unmanned research vehicle for higher maneuver performance at lower weight.

FY98: Complete both ground (full-scale) and wind tunnel (reduced-scale) tests of buffet load alleviation system to increase vertical tail fatigue life by a factor of 10.

FY99: Complete optimal design of tail buffet load alleviation system in preparation for flight test.

FY00: Complete adaptive structures wind tunnel testing: aerodynamic/weight/signature improvements.

FY03: Complete buffet alleviation flight test.

THRUST 4: FLIGHT CONTROL

User Needs

The Flight Control Thrust focus is to advance technology in control system design methods and criteria, hardware and mechanization of that hardware, and piloted air vehicle simulation to meet our customers' needs. Technology challenges include increased range, lethality, and survivability, accompanied by decreased costs and sustainability requirements.

The customer needs addressed in this thrust are identified in the following MAP documents:

- ACC's Theater Missile Defense MAP requires technologies to attack/kill multiple targets on a single pass.
- ACC's Strategic Attack/Air Interdiction MAP calls for increases in reliability while reducing system weight and supportability costs. Minimize support equipment to reduce airlift Counter Air requirements.
- Special Operations Command's (SOC) Provide Mobility of Forces in Denied Territory MAP requires new long-range, low observable aircraft designed to fight deep in the battlefield.
- ACC's Counter Air MAP requires weapon systems to operate in all environments on the ground and in the air (in all weather).
- Air Mobility Command's (AMC) Airlift MAP calls for electric actuators and fiber optics for lighter, smaller actuation controls.
- AETC has the requirement to improve networking performance for training simulators.
- The Air-to-Surface Technology Planning Integrated Product Team (TPIPT) Development Plan identifies uninhabited air vehicles as concept solutions to many operational needs.

Goals

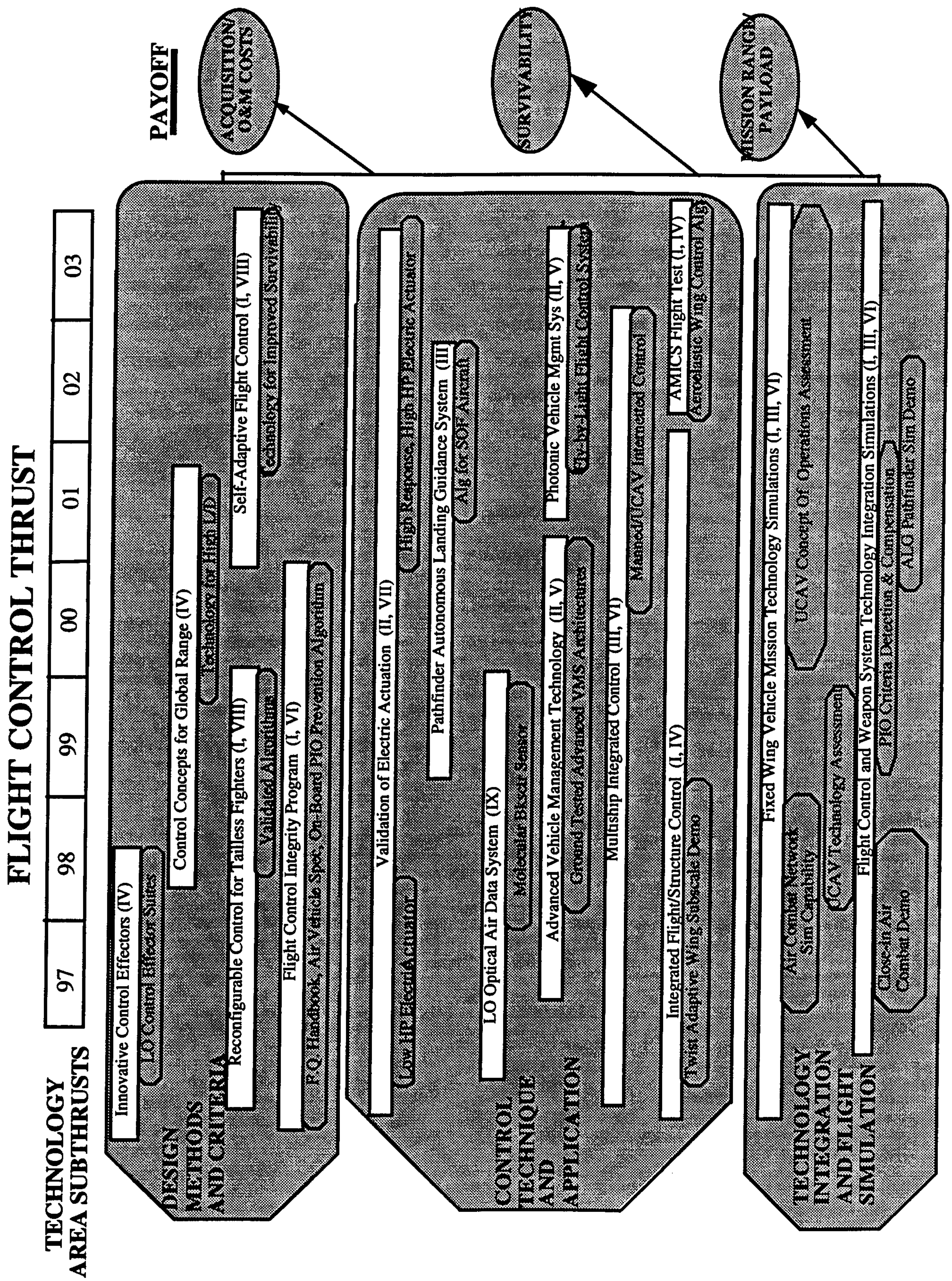
The primary goals of the Flight Control Thrust are to reduce air vehicle design, development, and sustainment costs and to improve combat mission effectiveness. The Flight Control Thrust has aligned these goals to National, Interservice, and Air Force user needs. These goals are grouped in technology areas of Design Methods and Criteria, Control Techniques and Applications, and Flight Control Technology Integration and Flight Simulation. The Flight Control Thrust will achieve the following goals for a class of baseline air vehicles (F-22, MC-130H, B-2, and C-17) by the year 2006:

I. 30% RED in flight control development costs
II. 150 lb. (500 lb. bomber) RED in flight control hardware weight
III. 70% RED in low visibility mission aborts
IV. 20% RED in lifting/control surface weight/drag
V. 50% RED in cannot duplicate maintenance actions
VI. 70% RED in control related accidents
VII. New capability: 45 HP Electric Actuation
VIII. New capability: Self-Adaptive Control
IX. New capability: LO Optical Air Data System

These goals are fully aligned with the DTO in the DTAP for Air Platforms.

Major Accomplishments

- Completed laboratory test of innovative molecular backscatter velocity, temperature, and pressure optical sensor. Supports the goal of an affordable LO flight control optical air data system.
- Flight validated low horsepower electro-hydrostatic actuator on left aileron of NASA F-18 in joint USAF, Navy, and NASA program. Supports ACC's need for increased survivability and decreased sustainment costs.
- Flight demonstrated the Intraformation Positioning System on 2 MH-53J helicopters and 2 MC-130H aircraft. Supports USSOCOM need for close air operations in adverse weather.
- Completed flight testing of Autonomous Landing Guidance System. Supports AMC and USSOCOM need for terminal area operations in low visibility.
- Completed wind tunnel testing and signature evaluation of new, low-drag control effectors for future strike aircraft. Supports goal of 30% reduced weight/drag of lifting and control surfaces.
- Completed VISTA F-16 limited flight test of reconfigurable control algorithms for conventional aircraft. Supports self-adaptive control new capability and 70% reduction in control related accidents.
- Completed Phase I of NT-33 HAVE PIO in-house simulations to develop enhanced piloted simulation techniques for PIO evaluation. Supports 30% reduction in flight control development costs.
- Completed PIO neural network detection and compensation concept demonstration. Supports 70% reduction in flight control related accidents.


FLIGHT CONTROL THRUST
TECHNOLOGY AREA SUBTHRUSTS
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PAYOFF
ACQUISITION/ O&M COSTS
SURVIVABILITY
MISSION RANGE/ PAYLOAD
DESIGN METHODS AND CRITERIA
Innovative Control Effectors (IV)
LO Control Effector Suites
Control Concepts for Global Range (IV)
Technology for High L/D
Reconfigurable Control for Tailless Fighters (I, VIII)
Validated Algorithms
Self-Adaptive Flight Control (I, VIII)
Technology for Improved Survivability
Flight Control Integrity Program (I, VI)
P.Q. Handbook, Air Vehicle Spec, On-Board PIO Prevention Algorithm
CONTROL TECHNIQUE AND APPLICATION
Validation of Electric Actuation (II, VII)
Low HP ElectriActuator
High Response, High HP Electric Actuator
Pathfinder Autonomous Landing Guidance System (III)
Alg for SOF Aircraft
LO Optical Air Data System (IX)
Molecular Optical Sensor
Advanced Vehicle Management Technology (II, V)
Ground Tested Advanced VMS Architectures
Photonic Vehicle Mgmt Sys (II, V)
Fly-by-Light Flight Control System
Multiship Integrated Control (III, VI)
Manned/UCAV Internetted Control
Integrated Flight/Structure Control (I, IV)
Twist Adaptive Wing Subscale Demo
AMICS Flight Test (I, IV)
Aeroelastic Wing Control Alg
TECHNOLOGY INTEGRATION AND FLIGHT SIMULATION
Fixed Wing Vehicle Mission Technology Simulations (I, III, VI)
Air Combat Network Sim Capability
UCAV Concept Of Operations Assessment
UCAV Technology Assessment
Flight Control and Weapon System Technology Integration Simulations (I, III, VI)
Close-in Air Combat Demo
PIO Criteria Detection & Compensation
ALG Pathfinder Sim Demo

Figure FC-1

Changes from Last Year

Changes from last year include a one year slip in the completion of electrohydrostatic and electromechanical actuators flight test. Another change was the deletion of 6.3 funding for the Affordable LO Optical Air Data System program resulting in a stretch of the 6.2 program. New DARPA funding for the high-power electrohydrostatic stabilator actuator has accelerated development and flight test pushing it ahead of the Intelligent Pump Actuation System. Work in control technology for high L/D transports has slipped 1 year due to funding shortages.

Milestones

The programs outlined in Figure FC-1 are grouped in their respective subthrust area. The following program milestones further expand the Goals section into specific quantifiable events by fiscal year.

Design Methods and Criteria

FY98: Complete revision of Flying Qualities Standard and Handbook, MIL-STD-1797B to support ACC's need for controlled flight at high angle-of-attack to increase survivability.

FY99: Conduct in-house assessment and piloted simulation of Innovative Control Effectors tailless aircraft. Supports ACC need to improve survivability.

FY99: Complete development of prototype, real-time, on-board PIO detection/compensation system. Supports ACC need to improve survivability.

FY00: Complete development of reconfigurable control algorithms for tailless aircraft. Supports ACC's need to improve survivability.

FY01: Complete study of flow control effector technology for high L/D transports to support AMC's need for increased range.

FY01: Complete VISTA flight test of tailless, reconfigurable control algorithms. Supports ACC's need to improve survivability.

FY02: Complete OT&E testing of PIO detection/compensation system to ensure absence of nuisance trips during operation. Supports 70% reduction in control related accidents.

Control Techniques and Applications

FY98: Develop critical software design specifications for Multiship Integrated Control to support ACC and AFOSR need for increased survivability and New World Vistas emphasis on unmanned air vehicles.

FY98: Complete optical air data flight experiments on diverse set of flight test platforms. Supports ACC need for reduced signature and cost.

FY98: Complete flight validation of low-horsepower electromechanical actuator on left aileron of NASA F-18. Supports ACC need for increased survivability and reduced sustainment costs.

FY99: Develop control system design methodology that integrates lightweight, flexible structures and advanced control techniques. This supports ACC, AMC, and AFSOC's needs for reduced weight and low observability.

FY00: Flight validate high horsepower Electro-Hydrostatic Actuator on flight critical control surface to reduce aircraft weight while improving survivability, reliability, and maintainability for ACC, AMC, and AFSOC.

FY01: Complete limited flight test demonstration of fundamental Multiship Integrated Control capabilities covering ground operations, take-off and recovery, rendezvous, and autonomous operations to support New World Vistas emphasis on UCAVs.

FY02: Flight validate high horsepower Intelligent Pump Electric Actuator on flight critical control surface in joint USAF and NASA electric program. Supports the ACC's and AMC's need to improve actuation reliability and supportability.

FY03: Complete laboratory validation of new photonic vehicle management system. Supports New World Vista emphasis on Fly-By-Light.

Flight Control Technology Integration and Flight Simulation

FY98: Demonstrate transatlantic, networked air vehicle combat simulation. Supports AETC need to improve networking performance.

FY99: Demonstrate the Uninhabited Combat Air Vehicle (UCAV) technology assessment simulation. Supports New World Vistas emphasis on UCAVs.

FY00: Conduct real-time operator-in-the-loop mission analysis of developing UCAV control decision aiding technologies. Supports New World Vistas UCAV concept.

FY01: Demonstrate PIO detection and compensation system. Supports ACC need to improve survivability.

FY02: Demonstrate pathfinder autonomous landing guidance system. Supports ACC need to operate in all weather.

THRUST 5: VEHICLE-PILOT INTEGRATION

User Needs

The Vehicle-Pilot Integration Thrust provides technology solutions to user needs stated in Mission Area Plans, Mission Need Statements, and Operational Requirement Documents of Air Force Operational Commands. Additionally, this thrust addresses requested support from Air Force System Centers, Air Logistic Centers, and other agencies such as DARPA, NASA, the Defense Mapping Agency, NIST, and industry. Its primary goal is to develop and demonstrate integrated crew system concepts, consisting of effective, affordable information displays and controls that reduce acquisition and support costs, enhance mission effectiveness, and increase survivability for current and future aircraft systems. Reports are made to the Air Vehicles TAP, as well as the Human Systems Interface section of the DoD TAP. Programs from the commands carried out in this thrust address 103 operational deficiencies that include:

- Air Combat Command: reduced operation and support costs, all-weather operations, real-time information, reduced crew workload, improved situation awareness, alternate control devices, rapid mission replanning, laser-hardened cockpit capabilities, helmet-mounted display information, on-board and off-board sensor information fusion, and improved, reliable multi-function displays.
- Air Mobility Command: increased reliability and maintainability, reduced crew workload, all-weather operations, improved cockpit avionics integration, improved intraformation positioning information, inflight mission planning and autonomous precision approach/landing capability.
- Air Education and Training Command: reduced operation and support costs, advanced display technologies, and support of weapon system training.
- Air Force Special Operations Command: advanced displays, improved night vision capabilities, reduced support costs, laser-hardened cockpit capabilities, reduced crew tasking, autonomous precision landing capability, enhanced imagery support, and integrated mission planning.

Goals

The Vehicle-Pilot Integration Thrust goals support the Human Systems Interface DoD DTAP goals and will achieve the following goals by the year 2005:

I. Develop vehicle-pilot integration to expand overall weapon system performance and exploit warfighter use of real-time off-board data in the cockpit while reducing or holding-constant aircrew workload.

II. Demonstrate the integration of advanced display concepts with non-conventional control techniques to enable in-flight mission planning and automated low-level flight for single-seat strike aircraft.

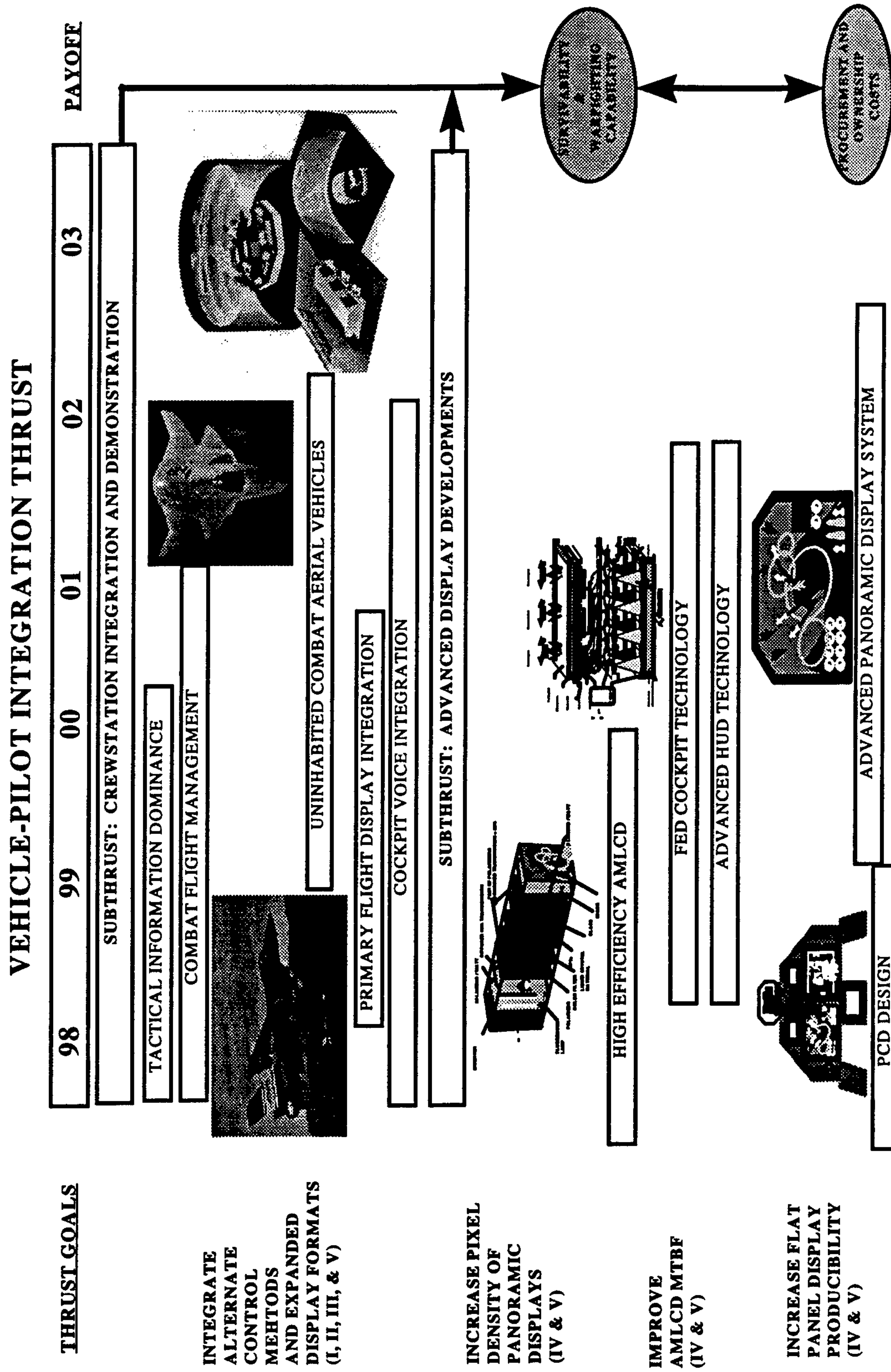
III. Develop crew systems to support the reduction of the two-seat (F-15E) fighter/attack to one seat.

IV. Develop large area, high definition, high situational awareness (SA) Active Matrix Liquid Crystal (AMLCD), Digital Micromirror Device (DMD), Gas Plasma (GP), Field Emissive Device (FED), and other flat panel displays for form, fit, function retrofit (F^3R) to existing aircraft and use in advanced aircraft. These displays will exhibit full sunlight readability and enable a 30-100 fold mean-time-between-failure (MTBF) improvement over today's electromechanical (EM) and cathode ray tube (CRT) displays.

V. Develop a UCAV operator station that enables a single operator to control up to four UCAVs in air-to-air or air-to-ground missions.

Major Accomplishments

- Successfully tested a missile trajectory prediction algorithm in piloted simulation evaluation.
- Completed joint work with NASA to perform speech recognition flight tests using two COTS speech systems on an OV-10 aircraft to test effects of G forces and noise.
- Developed and tested head-up display pathway symbology for weapon delivery and landing mission phases.
- Developed and evaluated a prototype Remote Interface Unit (RIU) for displaying and controlling near-real time information from on- and off-board sources in mobility cockpits.


VEHICLE-PILOT INTEGRATION THRUST
THRUST GOALS
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PAYOFF
INTEGRATE ALTERNATE CONTROL MEHTODS AND EXPANDED DISPLAY FORMATS (I, II, III, & V)
INCREASE PIXEL DENSITY OF PANORAMIC DISPLAYS (IV & V)
IMPROVE AMLCD MTBF (IV & V)
INCREASE FLAT PANEL DISPLAY PRODUCIBILITY (IV & V)
SUBTHRUST: CREWSTATION INTEGRATION AND DEMONSTRATION
TACTICAL INFORMATION DOMINANCE
COMBAT FLIGHT MANAGEMENT
UNINHABITED COMBAT AERIAL VEHICLES
PRIMARY FLIGHT DISPLAY INTEGRATION
COCKPIT VOICE INTEGRATION
SUBTHRUST: ADVANCED DISPLAY DEVELOPMENTS
HIGH EFFICIENCY AMLCD
FED COCKPIT TECHNOLOGY
ADVANCED HUD TECHNOLOGY
PCD DESIGN
ADVANCED PANORAMIC DISPLAY SYSTEM
SURVIVABILITY & WARFIGHTING CAPABILITY
PROCUREMENT AND OWNERSHIP COSTS

Figure VPI-1

- Integrated voice recognition and touch-sensitive display screens with traditional hands-on-throttle-and-stick (HOTAS) controls for single-seat fighters.
- Evaluated the feasibility of replacing conventional "upfront" control of communication/navigation functions in single-seat fighters with voice control.
- Demonstrated F^3 replacement of 9-in CRT with a polyplanar optic screen projection design using the DMD and a solid state green laser light source.
- Demonstrated a vacuum glass panel alignment and sealing system for rapid FED production.
- Demonstrated ruggedized flat panel display technology based on steel and plastic substrate to replace glass.
- Demonstrated a full color red-green-blue (RGB) Solid State Laser Light Source that will enable the development of sunlight readable displays.
- Demonstrated a three color organic LED source for military display applications.
- Designed 3-D autostereoscopic display for cockpit/crewstation based on pre-computed symbol sets.
- Demonstrated a high resolution 1280 x 1024 pixel, polysilicon AMLCD projection display system.
- Demonstrated 50% lower voltage inorganic electroluminescent display technology.
- Designed 5-in Air Transport Indicator (ATI) based on nascent field emission display technology.

Changes from Last Year

Based on reductions in budget, this thrust no longer includes work in the intelligent decision aiding technology area except for Small Business Innovation Research (SBIR) work. However, a plan was developed to reinitiate decision aiding work in FY99. Also, work previously referred to as Advanced Crew-Tailored Cockpit Concepts was broken down into two distinct programs starting in FY98. These are Primary Flight Display Integration and Cockpit Voice Integration.

Milestones

The milestones outlined in Figure VPI-1 are grouped in their respective subthrust areas. These milestones further expand the Goals section into more specific quantifiable events by fiscal year.

Crewstation Integration and Demonstration

FY98: Integrate voice control technology with the Off-board Cockpit Information Remote Interface Unit.

FY99: Evaluate voice-recognition technology and touch-sensitive display screens for enabling a single-seat pilot to efficiently and safely replan the mission in-flight.

FY99: Develop UCAV operator interface.

FY00: Demonstrate and evaluate a fully-integrated, multi-crew, all-glass interface incorporating voice control of selected mission functions (reroute, display and system management) and operated by a crew complement of two.

FY00: Improve integration of tactical situation displays, symbology, and information fusion to increase target kills by 50%.

FY01: Fully integrate voice recognition for application in single-seat crew station performing mission replanning, precision weapon delivery, and multiple target attack on a single pass.

FY01: Develop information controls and display formats that will enable a single UCAV operator to control up to four air vehicles in an air-to-air or air-to-ground scenario.

FY02: Demonstrate a full-mission capability of UCAV operator station.

FY02: Begin integrating the required display and decision aiding technologies into an "immersed" station that enables a single UCAV operator to control up to four UCAVs during Suppression of Enemy Air Defenses (SEAD) and Air Interdiction missions.

FY03: Demonstrate full-mission capability of the "immersed" UCAV operator station.

FY03: Fully integrate and qualify a primary flight reference that would allow pilots of single-seat aircraft the ability to attack multiple targets with multiple weapons in a single pass in night and in adverse weather.

Advanced Display Developments

FY98: Demonstrate technology for 2-fold increase optical efficiency of AMLCDs and demonstrate 15,000-hour MTBF improvement over current displays.

FY98: Demonstrate a high resolution/definition front panel UCAV mission operator display station.

FY99: Demonstrate 3-million pixel density for panoramic display.

FY99: Develop Advanced Micro Machined Display Engine (AMMDE) with 100,000 + hours MTBF.

FY00: Demonstrate compact, high brightness (> 300 foot Lamberts) Heads Up Display (HUD) using diffractive optical elements and high brightness FED.

FY00: Develop high speed graphics processor to enable UCAV vehicle operations.

FY01: Demonstrate Panoramic/Immersive Display System for crewstations.

FY02: Demonstrate projection system to use the canopy as a display system.

THRUST 6: VEHICLE SUBSYSTEMS

User Needs

The Vehicle Subsystems Thrust focuses on technology developments to decrease aircraft weight, increase mission range, reduce cost of ownership, and enhance survivability and safety, thus increasing warfighting capability. This Thrust acts as a catalyst to transition technology outside of DoD. This thrust develops technologies that address many of the subsystems issues associated with an air vehicle. These technologies include transparency systems, tires, wheels, brakes, landing gear struts, fire suppression, combat damage reduction, precision airdrop, thermal management, and component integrity.

The following requirements were extracted from Mission Area Plans, Technology Planning Integrated Product Team documentation and other sources of requirements information through the Wright Laboratory Product Technology Plan.

AIR MOBILITY COMMAND

- Birdstrike resistant transparencies.
- Improved airdrop accuracy.
- Better battle damage repair concepts.
- Cost effective weapon system availability.
- Reduced manufacturing and support costs.
- Improved reliability, maintainability, and supportability built into all components.

AIR COMBAT COMMAND

- Reduced manufacturing and support costs.
- Improved reliability, maintainability, and supportability built into all components.
- Airframe components that are easily repaired on the flightline.
- Enhanced battle damage repair concepts.
- Need for maintenance diagnostics.
- Birdstrike resistant transparencies with through-the-canopy ejection.

AIR EDUCATION & TRAINING COMMAND

- Birdstrike resistant transparencies with through-the-canopy ejection.
- Reduced manufacturing and support costs.
- Improved reliability, maintainability, and supportability built into all components.

AIR FORCE SPECIAL OPERATIONS COMMAND

- Improved airdrop accuracy.
- Reduced Manufacturing and support costs.
- Improved reliability, maintainability, and supportability built into all components.
- Improved environmental control system.
- Reduced aircraft weight and drag.

Goals

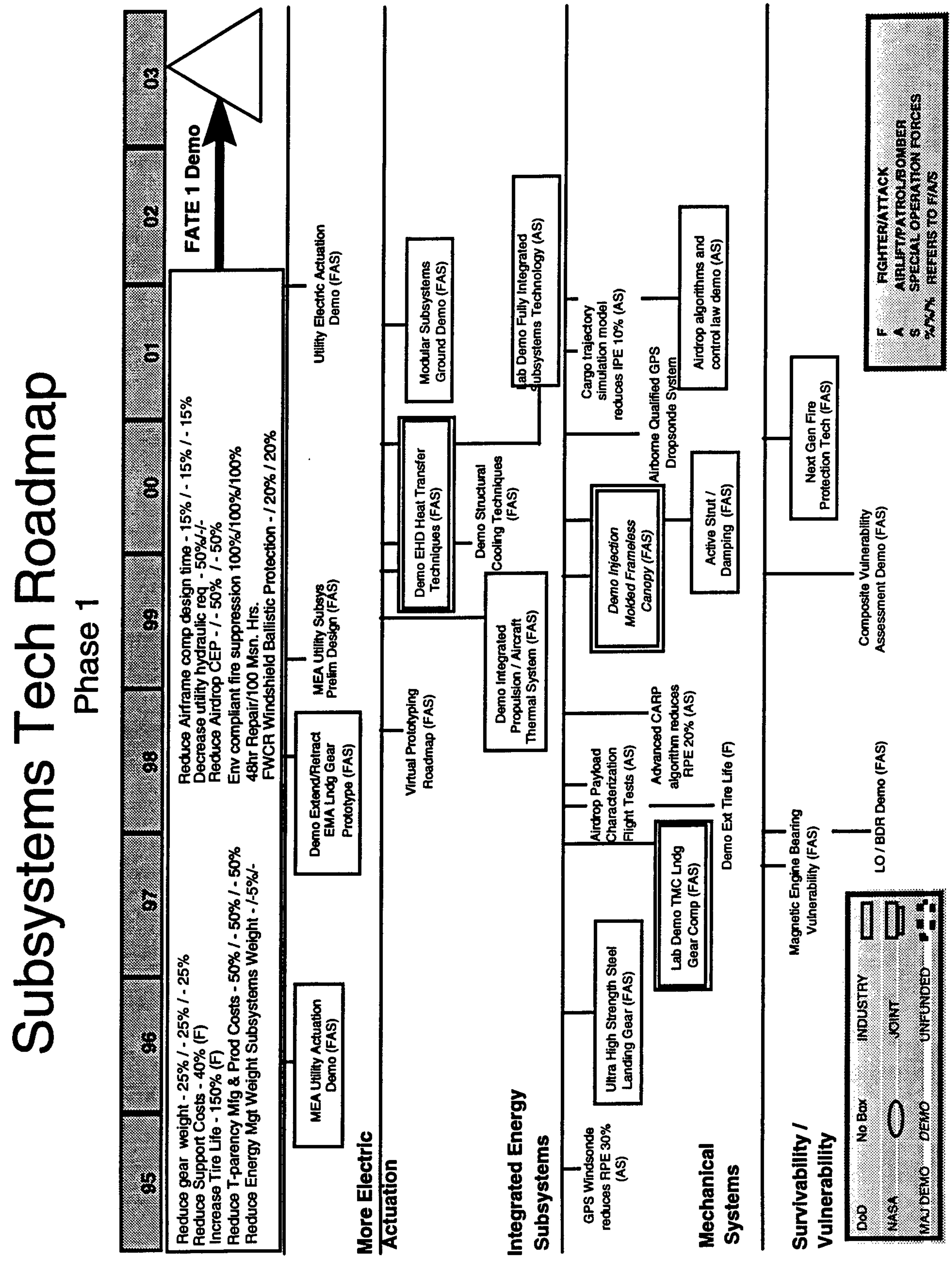
The Vehicle Subsystems goals are grouped in technology areas of More Electric Actuation, Integrated Energy Subsystems, Mechanical Systems, and Survivability/Vulnerability. Reduced manufacturing and support costs, and improved reliability, maintainability and supportability are an integral part of each of these areas. The goals listed below are targeted toward the F-22, F-18E/F, C-17, P-3, B-2, and MC-130H class aircraft and accomplished by 2006.

I. 30% RED in landing gear weight
II. 4X INC in energy efficiency
III. 50% RED in transparency O&M costs
IV. 20% RED in energy management subsystems weight
V. 25% RED in subsystems component design time
VI. 75% INC in air drop accuracy
VII. 50% RED in on/off loading manpower
VIII. 15% RED in armor weight
IX. 30% INC in windshield ballistic protection

These goals are fully aligned with the Defense Technology Objectives in the Defense Technology Area Plan for Air Platforms.

Major Accomplishments

- Completed Mission Environmental Requirements Integration Technology (MERIT) Operational Test and Evaluation (OT&E).
- Designed and fabricated high temp Phase Change Material (PCM) structural panel for reduced aircraft thermal emissions.
- Established penetration scaling laws for vulnerability assessment.
- Identified composite penetration and ballistic limit scaling laws universally applied to metals and plastics.



Subsystems Tech Roadmap
Phase 1
95
96
97
98
99
00
01
02
03
Reduce gear weight - 25% / - 25% / - 25%
Reduce Support Costs - 40% (F)
Increase Tire Life - 150% (F)
Reduce T-parency Mfg & Prod Costs - 50% / - 50% / - 50%
Reduce Energy Mgt Weight Subsystems Weight - /-5%/-
Reduce Airframe comp design time - 15% / - 15% / - 15%
Decrease utility hydraulic req. - 50%/-/-
Reduce Airdrop CEP - / - 50% / - 50%
Env compliant fire suppression 100%/100%/100%
48hr Repair/100 Msn. Hrs.
FWCR Windshield Ballistic Protection - / 20% / 20%
FATE 1 Demo
More Electric Actuation
MEA Utility Actuation Demo (FAS)
Demo Extend/Retract EMA Lndg Gear Prototype (FAS)
MEA Utility Subsys Prelim Design (FAS)
Utility Electric Actuation Demo (FAS)
Virtual Prototyping Roadmap (FAS)
Demo Integrated Propulsion / Aircraft Thermal System (FAS)
Demo EHD Heat Transfer Techniques (FAS)
Demo Structural Cooling Techniques (FAS)
Modular Subsystems Ground Demo (FAS)
Lab Demo Fully Integrated Subsystems Technology (AS)
Integrated Energy Subsystems
GPS Windsonde reduces RPE 30% (AS)
Ultra High Strength Steel Landing Gear (FAS)
Lab Demo TMC Lndg Gear Comp (FAS)
Airdrop Payload Characterization Flight Tests (AS)
Advanced CARP algorithm reduces RPE 20% (AS)
Demo Ext Tire Life (F)
Demo Injection Molded Frameless Canopy (FAS)
Active Strut / Damping (FAS)
Airborne Qualified GPS Dropsonde System
Cargo trajectory simulation model reduces IPE 10% (AS)
Airdrop algorithms and control law demo (AS)
Mechanical Systems
Survivability / Vulnerability
Magnetic Engine Bearing Vulnerability (FAS)
LO / BDR Demo (FAS)
Composite Vulnerability Assessment Demo (FAS)
Next Gen Fire Protection Tech (FAS)
DoD
No Box
INDUSTRY
NASA
JOINT
MAJ DEMO
DEMO
UNFUNDED
F FIGHTER/ATTACK
A AIRLIFT/PATROL/BOMBER
S SPECIAL OPERATION FORCES
%/%/% REFERS TO F/A/S

Figure VS-1

- Completed tri-service design methodology to implement first-generation Halon replacements for aircraft fire protection.
- Developed theory concerning structural failure thresholds under impulsive loads.
- Fabricated first Titanium Matrix Composite (TMC) F-18 nose landing gear drag brace piston.
- Completed fabrication and testing of first generation extended life F-16 main landing gear tire.
- Fabricated and installed specialized test equipment to demonstrate extended life of new tire design/test technology.
- Compressed vulnerability assessment for commercial aircraft fleet.

Changes from Last Year

Due to budgetary constraints, the following S&T portfolio changes were made: 1) canceled all programs related to ejection seat research and development. and 2) terminated all out year programs in landing gear and brake research and development. Reprioritized transparency systems programs into birdstrike avoidance systems. Initiated technology area to develop/apply electric actuation to utility subsystems. Proposed program new starts for FY98 include: Electrohydrodynamic Heat Exchanger Development and Transition, Birdstrike Warning Technology, Advanced Trajectory Simulation Model, Validation of Electric Actuation for Utility Subsystems, and GPS Dropsonde development.

Milestones

The milestones outlined in Figure VS-1, are grouped in their respective technology areas. These milestones further expand the Goals section into more specific quantifiable events by fiscal year.

More Electric Actuation

FY99: Electric actuation utility subsystem preliminary design.

FY01: Demonstrate more electric actuation for utility subsystems.

Integrated Energy Subsystems

FY98: Fabricate advanced composite material heat exchanger.

FY98: Complete subsystems integration design assessment roadmap.

FY99: Complete test of critical structural cooling component.

FY99: Validate advanced composite material heat exchanger efficiency.

FY00: Demonstrate passive cooling techniques for aircraft thermal management applications.

FY01: Demonstrate total energy analysis model of subsystems.

FY01: Demonstrate actively controlled full-scale heat exchangers.

FY02: Define distributed aircraft cooling concept.

FY03: Demonstrate rapid virtual modeling and assessment of subsystems.

FY03: Demonstrate high intensity heat-transfer techniques to effectively miniaturize heat exchanger weight/volume.

Mechanical Systems

FY98: Fabricate injection molded canopy.

FY98: Demonstrate transparency material recycling.

FY98: Precision aerial delivery demonstration.

FY98: Demonstrate an F-16 tire with double the number of landings of current tires.

FY99: Demonstrate birdstrike warning system.

FY99: Ground demo injection molded canopy.

FY99: GPS dropsonde operational prototype system completed.

FY01: Computed Air Release Point algorithm validated through flight testing.

FY02: Integrated precision aerial delivery system validated.

FY02: Demonstrate integrated birdstrike detection and warning system.

Survivability / Vulnerability

FY97: Demonstrate weapons-bay survivability from a ballistic impact munition.

FY97: Transition first principles-based algorithms into the Advanced Joint Effectiveness Model (AJEM) vulnerability code.

FY97: Demonstrate machine vision overheat and fire detection for dry bays.

FY98: Demonstrate Halon 1301 replacement for F-16 fuel tank ullage.

FY98: Demonstrate low cost lightweight wet pipe fire extinguishing concept.

FY98: Develop methods for Aircraft Battle Damage Repair (ABDR) of thermosetting composites.

FY99: Develop composite laminate failure criteria.

FY99: Composite vulnerability assessment demonstration.

FY99: Demonstrate composite-ram response prediction methods.

FY00: Develop stress wave damage attenuation methods for composite laminates.

FY01: Develop hydrodynamic ram damage reduction criteria.

THRUST 7: AIR BASE TECHNOLOGY

User Needs

Air Base Technology supports the Air Force mission in two core competencies: Rapid Global Mobility and Agile Combat Support. R&D products from this thrust are critical to the success of the Air Expeditionary Force. R&D payoffs are measured in terms of:

- reduced airlift requirement for deployment of air mobile systems (reduced cost, weight, cube, and set-up time),
- reduced logistics and manpower requirements for sustainment of an air base (reduced fuel requirements), and
- enhanced protection for deployed personnel and critical assets.

The thrust addresses deficiencies as prioritized by the Air Force readiness community and documented in numerous SONs and ORDs. Documented user needs include Advanced Air Mobile Power and Shelter Systems, a New Generation of Firefighting and Crash Rescue Systems, and Halon Replacements.

Projects in this thrust area are carefully selected to produce critical technology in specific areas where industry is not (and will not) provide commercial alternatives.

Goals

The goals of this thrust are in two major categories: Fire Fighting and Air Mobile Systems. The goals listed will be accomplished by FY03.

Fire Fighting

I. *Fire Suppression Technology.* Develop improved fire fighting agents, equipment, and techniques to protect weapons systems against current and emerging operational and wartime threats.

II. *Firefighter Protective Equipment and Training.* Develop new protective clothing for firefighters that exploits new developments in phase change materials. Develop training tools based on virtual reality to increase the effectiveness of home station training.

Air Mobile Systems

III. *Lightweight Systems for Contingency Base Power Generation and Distribution.* Develop alternate power production technologies that are lighter and require less fuel. Develop fuel reformer technology to convert combat fuels to power fuel cells. Develop advanced solar film technology for use on shelter coverings to produce passive power. Reduce the weight of power distribution systems.

IV. *Air Transportable Shelter Systems.* Develop lightweight air-inflatable structures technology with chemical/biological protection. Develop lightweight, highly efficient environmental control units that reduce deployment and sustainment logistics. Develop air deployable expandable frag protection. Exploit insulating composite materials, high-pressure airbeam structures, acoustic cycle heat pump, and electrohydrododynamic heat transfer.

All efforts in this area are fully aligned with Defense Technology Objectives for Materials and Processes.

Major Accomplishments

- Demonstrated enhanced large frame aircraft fire fighting capabilities.
- Completed Design & Phase I testing of the Advanced Fire Protection Deluge System, a joint program with the U.S. Army.
- Identified brominated alkenes and brominated unsaturated ethers as the most promising families of tropodegradable halocarbons for drop-in replacement for Halon 1211 used in 150 pound flightline fire extinguishers.

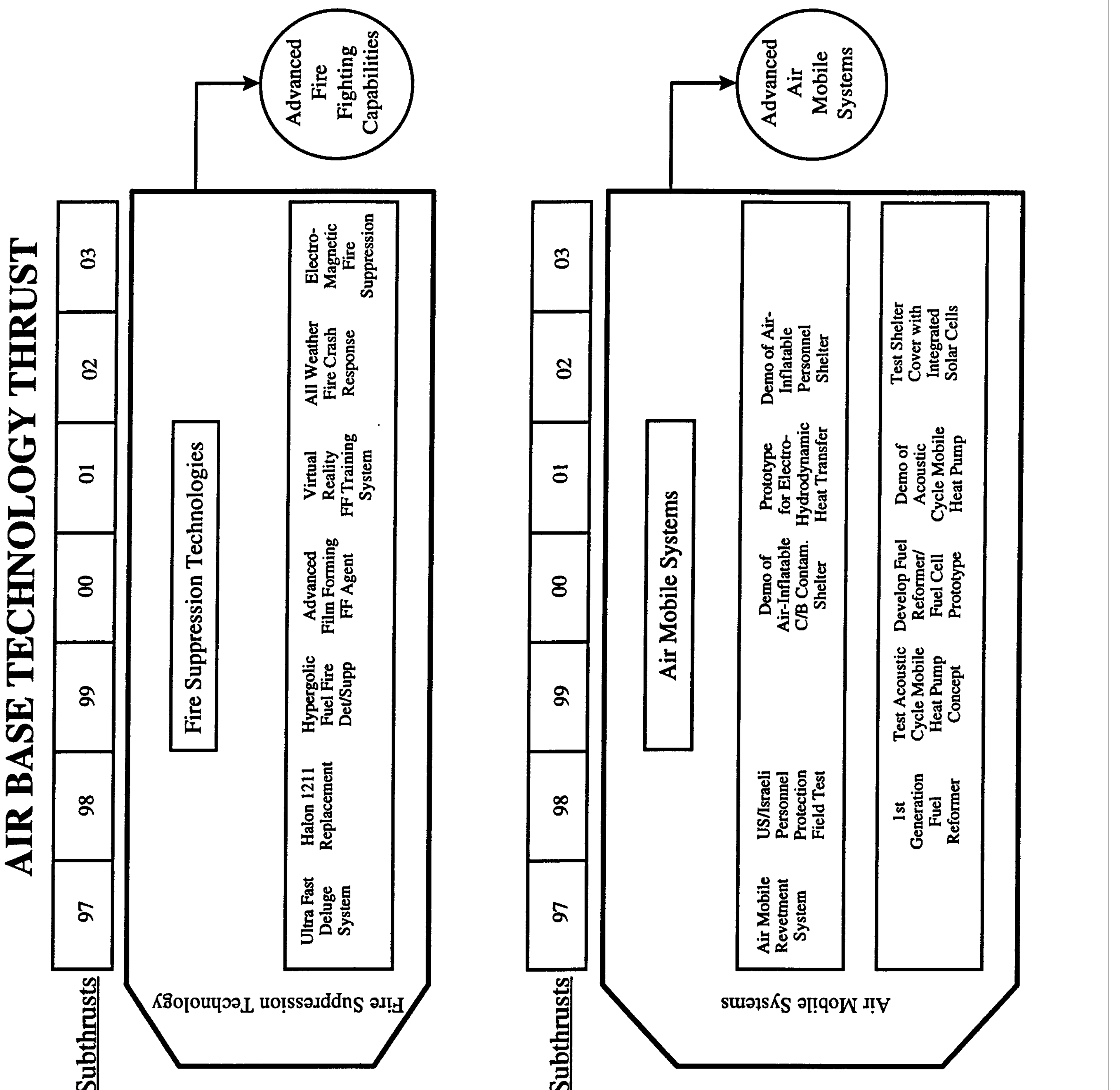

AIR BASE TECHNOLOGY THRUST
Subthrusts
97
98
99
00
01
02
03
Fire Suppression Technology
Fire Suppression Technologies
Ultra Fast Deluge System
Halon 1211 Replacement
Hypergolic Fuel Fire Det/Supp
Advanced Film Forming FF Agent
Virtual Reality FF Training System
All Weather Fire Crash Response
Electro-Magnetic Fire Suppression
Advanced Fire Fighting Capabilities
Air Mobile Systems
Air Mobile Systems
Air Mobile Revetment System
US/Israeli Personnel Protection Field Test
Demo of Air-Inflatable C/B Contam. Shelter
Prototype for Electro-Hydrodynamic Heat Transfer
Demo of Air-Inflatable Personnel Shelter
1st Generation Fuel Reformer
Test Acoustic Cycle Mobile Heat Pump Concept
Develop Fuel Reformer/ Fuel Cell Prototype
Demo of Acoustic Cycle Mobile Heat Pump
Test Shelter Cover with Integrated Solar Cells
Advanced Air Mobile Systems

Figure ABT-1

- Performed proof-of-principle experiments to demonstrate the feasibility of using magnetic fields to suppress fires.
- Demonstrated first generation acoustic cycle mobile heat pump that uses an induced pressure wave, allowing a single-phase refrigerant such as helium to achieve both thermodynamics heating and cooling.
- Conducted initial joint U.S./Israeli tests of personnel survival concepts for above ground structures against terrorist and scud delivered weapons.
- Designed and completed explosive tests on air mobile aircraft revetments for contingency bases.
- Completed prototype of man-portable ground penetrating radar (GPR) system for use by Combat Control Teams to evaluate contingency site runways.

Changes from Last Year

The Air Base Technology Thrust was refocused to concentrate on technologies to support the fire fighting and deployment missions. The Energy Technology and Pavements and Facilities sub-thrusts contained in the prior year's TAP were combined into the Air Mobile Systems subthrust. This subthrust will focus on lightweight rapidly deployable energy and shelter technologies required to support contingency operations. The Air Force will rely on the Army for pavements and facilities technologies. Liaison positions were established with the Army to address AF requirements.

Due to budget constraints air mobile systems research was minimally funded beginning in FY98. Goals, milestones, and roadmaps for these technologies were adjusted to reflect reduced investments.

Milestones

The milestones, outlined in Figure ABT-1, further expand the Goals section into more specific quantifiable events by fiscal year.

Fire Fighting

FY97: Demonstrate ultra-fast water deluge fire detection/suppression system for DoD munitions plant.

FY98: Demonstrate replacement for Halon 1211.

FY99: Demonstrate a hypergolic fuel fire detection/suppression system.

FY00: Complete exploratory development of a more effective, fully biodegradable film forming foam fire suppressant.

FY01: Demonstrate a virtual reality fire fighting training system.

FY02: Demonstrate a day-night all weather emergency response fire crash rescue capability.

FY03: Demonstrate an electromagnetic fire suppression system.

Air Mobile Systems

FY98: Complete testing of 1st generation fuel reformer. Full-scale field test of joint U.S. Israeli expedient personnel protection methods.

FY99: Complete proof-of-concept testing for acoustic cycle mobile heat pump.

FY00: Demonstrate prototype air-inflatable shelter for C/B contamination control area. Develop full-scale prototype fuel reformer.

FY01: Complete lab-scale prototype for electrohydrodynamic heat transfer. Demonstrate advanced prototype acoustic cycle heat pump.

FY02: Demonstrate air-inflatable personnel shelter. Test shelter covering with integrated solar cells.

GLOSSARY

ACC	Air Combat Command
ABDR	Aircraft Battle Damage Repair
ACS	Air Combat Supremacy
AETC	Air Education Training Command
AFMC	Air Force Materiel Command
AFMPP	Air Force Modernization Planning Process
AFOSR	Air Force Office of Scientific Research
AFSOC	Air Force Special Operations Command
AFSPC	Air Force Space Command
AFTA	Advanced Fixed Wing Technology Activities
AGE	Aircraft Ground Equipment Activities
ALAFS	Advanced Lightweight Aircraft Fuselage Structures
AMC	Air Mobility Command
AMLCD	Active Matrix Liquid Crystal Display
AMMDE	Advanced Micro Machined Display Engine
AOA	Angle-of-Attack
ASC	Aeronautical Systems Center
ASTROS	Automated Structural Optimization System
ATI	Air Transport Indicator
ATROHS	Advanced Technology Redesign of Highly Loaded Structures
CAI	Composites Affordability Initiative
CAS	Conformal Array Seeker
CASDAT	Conceptual Aircraft System Design Analysis Toolkit
CFD	Computational Fluid Dynamics
CFM	Combat Flight Management
CMC	Ceramic Matrix Composite
COTS	Commercial-off-the-Shelf
CRT	Cathode Ray Tube
DARPA	Defense Advanced Research Projects Agency
DEA	Data Exchange Agreement
DMD	Digital Micromirror Device
DoD	Department of Defense
DTAP	DoD Technology Area Plan
DTO	Defense Technology Objective
EM	Electromechanical
EMD	Engineering and Manufacturing Development
FAA	Federal Aviation Administration
FATE	Future Aircraft Technology Enhancements
FED	Field Emissive Device
FI	Flight Dynamics Directorate
F^3R	Form, Fit, Function Retrofit
FWV	Fixed Wing Vehicle
GP	Gas Plasma
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HOBS	High Off-BoreSight
HOTAS	Hands On Throttle and Stick
HP	Horsepower
HQ	Headquarters
HSCT	High Speed Civil Transport
HUD	Heads Up Display
HyTech	Hypersonic Technology Program
IEA	Information Exchange Agreement
IPT	Integrated Product Team
JACG	Joint Aeronautical Commanders Group
JSF	Joint Strike Fighter
LaRC	Langley Research Center
LED	Light Emitting Diode
LO	Low Observable
MAJCOM	Major Command
MAP	Mission Area Plan
MDD	Multi-Disciplinary Design
MEA	More Electric Actuation
MERIT	Mission Environmental Requirements Integration Technology
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MTBF	Mean-Time-Between-Failures
NASA	National Aeronautics & Space Administration
NASA DFRC	NASA Dryden Flight Research Center
NIST	National Institute of Standards & Technology

ODDR&E	Office of the Director for Defense Research & Engineering
ORTIP	Operational Requirements Technology Investment Plan
OT&E	Operational Test and Evaluation
P&W	Pratt & Whittney
PCM	Phase Change Material
PIO	Pilot Induced Oscillation
POD	Planar Optic Display
PVI	Pilot/Vehicle Interface
RCS	Radar Cross Section
R&D	Research and Development
RDT&E	Research Development Test & Evaluation
RGB	Red-Green-Blue
RIU	Remote Interface Unit
SA	Situational Awareness
SAB	Scientific Advisory Board
SBIR	Small Business Innovation Research
SEAD	Suppression of Enemy Air Defenses
S&T	Science & Technology
SID	Society for International Display
SOC	Special Operations Command
SOF	Special Operations Forces
SPO	System Program Office
3-D	Three Dimensional
TACID	Tactical Information Dominance Program
TAFT	Today's Aircraft Flying Tomorrow
TAP	Technology Area Plan
TAV	Transatmospheric Vehicle
TAWS	Twist Adaptive Wing System
TDA	Technology Development Approach
TEO	Technology Executive Officer
TMC	Titanium Matrix Composite
TMP	Technology Master Plan
TOGW	Take Off Gross Weight
TPIPT	Technology Planning Integrated Product Team
TRP	Technology Reinvestment Program
TPS	Thermal Protection System
TTO	Technology Transition Office
UAV	Unmanned Air Vehicle
UCAV	Unmanned/uninhabited Combat Air Vehicle
USSOCOM	US Special Operations Command
UTA	Unmanned Tactical Aircraft
V&V	Validation & Verification
VCATS	Visual Cueing & Targeting System
VHOBS	Very High Off BoreSight
VISTA	Variable-Stability In-Flight Simulator Test Aircraft
VSTOL	Vertical/Short Take Off/Landing
WL	Wright Laboratory
WVR	Within Visual Range

INDEX

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